*Christopher's*

# MINOR SURGERY

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*And*

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# MINOR

# SURGERY

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# Preface

There has been much deliberation concerning the title of the present edition. As was stated in the preface to the Seventh Edition, "minor surgery" is a poor designation, because no surgery is "minor," at least as far as the patient is concerned.

It has been the purpose of this text to consider those conditions that can be and should be diagnosed and treated in a physician's office, in an outpatient department of a hospital or in a patient's home. Many patients will be ambulatory, but many will not. Those maladies that require hospitalization for diagnosis or therapy are not discussed. The busy practitioner, the house officer on an outpatient service and the medical student need, for quick reference, a text concerning diagnosis and treatment of surgical disorders that do not require hospitalization.

In the present edition, changes consistent with constructive criticisms of the Seventh Edition have been made. The authors and publishers are extremely grateful for those suggestions and criticisms. Most of the chapters have been revised extensively. In the chapter on arterial diseases, arteriosclerosis, which is such a common condition, is discussed fully. Three completely new chapters, Injuries of the Hand, Diseases of the Breast and Physical Treatment in Minor Surgery, have been added.

Most of the authors, to whom we are extremely grateful for their efforts and contributions, are members of the Faculties of the School of Medicine of Tulane University and the College of Medicine of Baylor University. Dr. Champ Lyons is Professor of Surgery at the University of Alabama, Dr. John Howard is Professor of Surgery at Hahnemann Medical College and Dr. B. W. Haynes, Jr., is Assistant Professor of Surgery at the Medical College of Virginia.

We are greatly indebted to Miss Selma DeBakey, Director of the Editorial Divi-

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ALTON OCHSNER, M.D.
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*Part I*

# General Considerations

*Chapter 1*

# Equipment

*By Oscar Creech, Jr.*

A number of factors influence selection of equipment for a surgical office or clinic. One of the most important considerations is the type of hospital facilities available to the physician. If operating rooms and emergency rooms are available in local hospitals, office surgery will generally be restricted to simple procedures requiring little equipment On the other hand, if adequate hospital facilities are not available, the physician may be compelled to perform more extensive operations in the office. Under these circumstances a greater variety of equipment and supplies will be needed. However, physicians who work in the emergency rooms and surgical outpatient clinics of the general municipal hospitals have found that equipment for most minor surgical procedures need not be elaborate. In these institutions, the heavy patient load demands that operating and treatment rooms function efficiently. At the same time, acceptable technical standards must be maintained. For this reason, the instruments, supplies and furnishings are relatively simple and usually have a multipurpose nature. An attempt has been made here to follow this idea in compiling the lists of equipment, and in this respect they may be considered basic lists. The needs of the individual physician will determine the necessity for supplementing them

## INSTRUMENTS AND SUPPLIES

### Instruments

As the lesions to be treated will generally be small and readily accessible, minor surgical instruments should be small. In addition, although use of fine instruments does not insure meticulous operative technique, it tends to encourage more careful handling of tissues—a factor of no less importance when the operative procedure is a minor one.

The quantity of each of the instruments required depends largely upon the number of minor surgical operations performed. The quantities recommended here will provide two basic instrument sets, instruments for wound dressings and for certain diagnostic procedures, and a few items that are less frequently used but are nevertheless essential.

Practically all surgical instruments are available in both chromium plate and stainless steel. Because of its durability and complete resistance to corrosion, stainless steel is preferred, although the initial cost is greater than that of chromium plate.

*Instrument List*

Hemostatic forceps
- 6 Kelly, 6-inch, curved or straight
- 12 Halstead mosquito, 5-inch, 6 curved, 6 straight

Scissors
- 2 Mayo, 5½-inch, 1 curved, 1 straight
- 1 Strabismus, curved, blunt points
- 2 Suture, 1 blunt, 1 sharp point
- 1 Bandage

Knife blades, Bard-Parker, Nos. 10, 11, 15

Knife handles, No. 3

Retractors
- 4 Senn, double-ended, 5-inch
- 2 Parker, small
- 2 Mastoid

4 skin hooks

4 Forceps, thumb, dressing, 4½-inch

2 Forceps, tissue, 4½-inch

1 Forceps, splinter, fine point, 4-inch

2 Forceps, tissue, Adson

6 Forceps, Allis, 6-inch

2 Needle holders, small, 5½-inch

Surgical needles
- Keith, abdominal, 1½-inch
- Regular surgeon's, small and medium cutting edge, ⅜ and ½ circle

Regular surgeon's, small and medium taper point, ½ circle
8 Towel forceps, Jones or Backhaus
3 Probes, with eye, 5-inch
2 Grooved directors, with probe point, 5 inch
1 Curet, bone, small
1 Rongeur, bone, single-action, small
Boehme rectal diagnostic and treatment set
Rectal biopsy forceps
Paracentesis trocars
Vaginal specula
2 Three-way stopcocks
Spinal manometer
Pick-up forceps and container

SUPPLIES

*Sutures.* A variety of suture materials is available, but for minor surgical procedures, cotton and black silk are preferred. The greater tensile strength of these nonabsorbable materials permits use of fine sutures, and the relative absence of tissue reaction excited by them is favorable to wound healing. Ordinary cotton sewing thread,* No. 40 quilting and No. 70, and black silk 000 and 0000, are the types and sizes most commonly employed. Cotton thread has the advantages of low initial cost and availability, and since it has proved completely satisfactory for surgical purposes, it is the suture material of choice.[1] Both cotton and silk are purchased in spool lots. In addition, 0000 dermal silk with a fine swaged-on cutting needle and several tubes of small (000) catgut should be kept on hand.

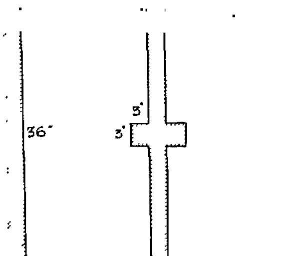
* Either Clark's O.N.T. or J & P Coats

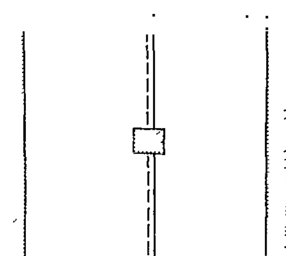
*Syringes and Needles.* Syringes of 2, 5 and 10 cc. are commonly used for injections and for administration of local anesthetic agents. At least two each of these sizes will be required. The larger (30 cc. and 50 cc.) syringes are primarily used for paracenteses, and only one each will be needed. A 10 cc. one-hand control syringe is desirable for local infiltration anesthesia. With the exception of the 2 cc. size, all syringes should be of the Luer-Lok type.

The following needles should be available:

No. 26—½-inch
No. 22—2½-inch
No. 20—2-inch
No. 18—2- and 3-inch
No. 15—3½-inch
No. 13—3½-inch

*Linens.* The operative field is draped with either hand towels or muslin sheets. The latter are made of heavy unbleached




Muslin sheets used to drape the operative field.

muslin 24 or 36 inches square with an opening 3 to 5 inches square placed in the center of one free border (Fig. 1). Two of these drapes are used together so that the openings oppose one another. Thus, the size of the openings can be varied to expose the operative area.

Covers for the Mayo stand and instrument tray are made of double thickness muslin. Single sheets, either muslin or percale, are needed for the operating and examining tables and for covering the patient. Pillows should be of foam rubber and covered with first a plastic, then a muslin or percale case. Patient's gowns should be roomy and fasten by ties in the back. The short-sleeved, slip-over type of intern shirt is useful as an operating jacket, and a plastic apron will occasionally be needed to protect the clothing of the surgeon.

*Dressings, Bandages and Splints.* The 4- by 4-inch gauze squares and the 4- by 8-inch gauze compresses are used for surgical sponges and wound dressings. They are made of 20- by 12-inch gauze and can be purchased already folded or may be made from bolt gauze. Several sizes and shapes of the commercially prepared bandages consisting of elastic adhesive with gauze compress attached should be available. As this type of bandage is water repellent, it is particularly useful for dressing small wounds of the hands. Fine (44) mesh gauze is used for dressing burns and large granulating wounds.

Two grades of absorbent cotton are needed. The long staple high-grade absorbent cotton should be used for antiseptic swabs or as pledgets for cleansing wounds. A cheaper grade of cotton can be employed as a filler for wound dressings and as padding for splints.

Gauze roller bandage in 1-, 2- and 3-inch widths, adhesive tape in ½-, 1-, 2- and 3-inch rolls, elastic bandages and elastic adhesive are employed for bandaging and dressings. Plaster of paris splints in 4-inch and 6-inch widths, basswood splints and Mason's Universal Hand Splints are needed for applying immobilizing dressings. Sheet wadding and either felt or foam rubber are used for padding.

In addition to these materials, zinc-gelatin bandages for the application of compression boots, muslin squares for slings and cellophane for use in occlusive dressings are desirable.

*Miscellaneous*

- Surgeon's gloves
- Surgical caps and masks
- 1 Graduate, 1000 cc.
- 2 Instrument trays, approximately 9 by 5 by 2 inches
- 6 Medicine glasses
- 1 Mayo tray
- 2 Dressing jars, 3½ qt., for towels and gauze squares
- 4 Utility jars for swab sticks, tongue blades, cotton and alcohol sponges
- 1 Instrument sterilizing jar
- 1 Knife blade sterilizing jar
- Culture tubes
- Biopsy specimen jars
- Glass slides
- Dakin tubes
- Safety pins
- Rubber dam for drains
- Urethral catheters

## STERILIZATION

Surgical instruments and supplies can be sterilized by the use of boiling water, steam under pressure (autoclave) or germicidal solutions.[2]

*Boiling.* Boiling instruments in a nonpressure sterilizer is widely employed because of its simplicity. This method is particularly adaptable to sterilization of hypodermic syringes, needles and other articles which are used frequently. However, only vegetative bacteria are destroyed by boiling, and unless special precautions are taken, metal instruments become corroded.

If an autoclave is not available or minor surgical procedures are performed infrequently, this method of sterilization can be used for instruments and other heat-resistant articles. Vegetative bacteria are destroyed by boiling for 30 minutes. Addition of 2 per cent solution of sodium carbonate, by raising the boiling point of the water, reduces this time to 15 minutes. *Addition of this alkaline* agent, and reduction of the oxygen con-

tent of the water by boiling for 5 minutes before the instruments are placed in the sterilizer, will significantly reduce the corrosive action.

*Autoclaving.* Sterilization by steam under pressure is the most effective method of destroying both vegetative bacteria and spores. As the articles can be dried promptly after sterilization, surgical packs can be prepared and stored, a factor of considerable importance when operative procedures are frequently performed. Furthermore, autoclaving is the only practical method of sterilizing gloves and linens. Autoclaving at a temperature of 250° F. under a pressure of 15 lb. per square inch for 15 minutes destroys both vegetative bacteria and spores. Linen packs must be autoclaved for 30 minutes because of the additional time required for the steam to penetrate to the center of the pack.

*Germicidal Solutions.* There are a number of germicidal solutions in which instruments can be sterilized by immersion for periods of 30 minutes or longer. This method destroys vegetative bacteria but is somewhat less effective against spores. Alcohol (70 per cent solution) is one of the most effective solutions, destroying vegetative bacteria in 30 minutes; but its rapid evaporation and its corrosive action on metal are distinct disadvantages. It is most widely used for sterilizing knife blades, needles and electrical equipment. Bard-Parker germicide (0.5 per cent G-11 in 8 per cent formaldehyde with isopropanol) and aqueous Zephiran chloride, 1:1000 solution, are effective agents which have no corrosive action and in which instruments can be kept indefinitely. Vegetative bacteria are destroyed in 30 minutes by these solutions, and resistant spores are killed within 3 hours by the Bard-Parker germicide.

The sterilization methods employed will be determined largely by the facilities available. The following procedures for preparation and sterilization of instruments and supplies have proved satisfactory in a surgical outpatient clinic as well as in office practice.

*Instruments.* The instruments listed below are placed in a tray and packed as shown in Figure 2 for autoclaving. From this pack, the basic minor surgical set is made up by the addition of cutting instruments, syringes and sutures.

- 6 Mosquito forceps
- 2 Kelly forceps
- 2 Skin retractors
- 2 Skin hooks
- 4 Towel forceps
- 1 Dressing forceps
- 1 Adson tissue forceps
- 1 Knife handle, No. 3
- Surgical needles
  - 1 Keith, abdominal
  - 2 small cutting ½ circle
  - 2 small round ½ circle
- 1 Needle holder
- 2 Medicine glasses
- 1 Grooved director with probe point

In addition, dressing and tissue forceps, a hemostat, probe and No. 3 knife handle are kept in germicidal solution, either in the same container with the scissors or separately, for use in wound dressings, removal of sutures, incision



*Figure 2* *a,* Instruments are prepared for autoclaving by placing them in a small metal tray *b,* The tray is wrapped in muslin for autoclaving.

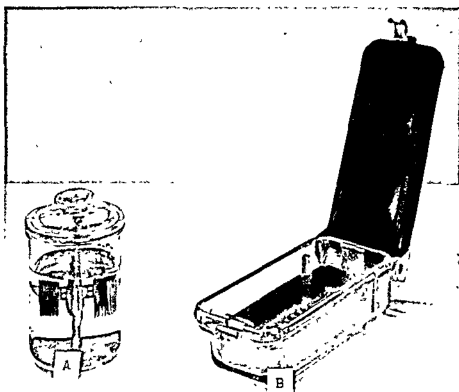



*Figure 3. A,* Knife blades are placed on a rack which is immersed in a jar of germicidal solution The rack can be lifted out and a sterile blade removed with pickup forceps *B,* Scissors are sterilized separately by immersion in a germicidal solution in a covered container

and drainage of abscesses, and other procedures which do not require a complete instrument set.

*Scissors and Knife Blades.* As cutting instruments are dulled by boiling and autoclaving, they are sterilized by immersion in germicidal solution. Glass containers are available which have tight-fitting covers to reduce evaporation (Fig. 3).

*Syringes and Needles.* These may be sterilized either by boiling or autoclaving. Small syringes (2 cc.) which are used for injection of medications should be boiled together with needles. Other syringes are prepared by removing the plunger from the barrel, wrapping in muslin, and autoclaving. Needles are put up in glass tubes which are stoppered with cotton and autoclaved.

*Sutures.* Cotton or silk is cut into 18-inch lengths and put up eight sutures to a package; or a single 12-foot length can be packaged and then cut into the desired suture length at the time of operation. Spores may lodge in the crevices of the strands of both cotton and silk; therefore, sterilization should be accomplished by autoclaving. Since these materials contract with heat, they should not be wrapped tightly about reels of

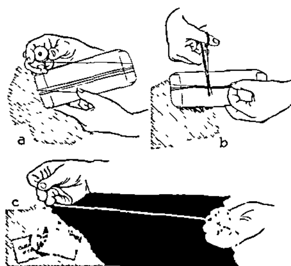



*Figure 4 a,* Cotton sewing thread is wrapped around a 9-inch length of basswood splint eight or ten times *b,* The strands are *held together* by two ligatures approximately 2 inches apart, between which the suture material is cut *c,* The 18-inch lengths of suture material are twisted

is then labeled and autoclaved

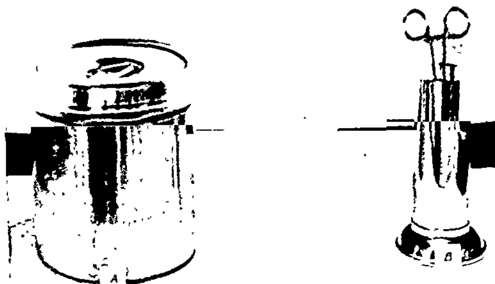


*Figure 5.* *A*, Sponges and towels are autoclaved and stored in a 5 quart stainless steel canister. *B*, The blades of the pickup forceps are kept sterile by immersion in a container of germicidal solution.

metal or wood for autoclaving. When suture lengths are cut prior to packaging, they can be twisted, coiled loosely and placed in a small paper envelope (Fig. 4). The single 12-foot length can be wrapped about a square of thin cardboard before placing it in the envelope. Cotton should not be re-sterilized more than once, and silk no more than three or four times, since the tensile strength is reduced by repeated sterilization.

*Linens.* Gowns, sheets, instrument tray covers and operative drapes are wrapped separately and autoclaved. Towels, gauze sponges, cotton balls, tongue blades and swab sticks are put up in metal or glass jars and autoclaved. For towels and sponges, 3½ or 4½ qt. containers are used (Fig. 5), and smaller canisters for the other items. If desired, towels may be wrapped in muslin, two to a package, and gauze sponges in muslin or paper, six to a package, for autoclaving (Fig. 6).

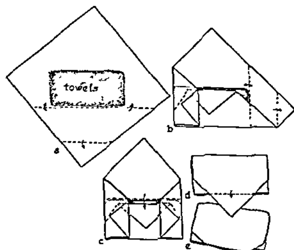



*Figure 6* Towels are wrapped in a muslin sheet or in heavy paper.

*Gloves.* Surgeon's gloves should be washed in warm, soapy water, rinsed in cold water, and dried thoroughly. They must be powdered on both sides with an absorbable starch powder such as "Bi-Sorb" rather than talcum. The cuffs of the gloves are turned back a distance of 2 inches and they are placed in a muslin envelope wrapper. A small amount of "Bi-Sorb" (½ teaspoonful) is wrapped in a paper towel and placed in one side of the glove wrapper in such a way that it can be removed without contaminating the gloves.

## FURNITURE

In Figure 7, an arrangement of furniture in an operating room is shown. Although varieties of designs and materials are available, operating room furniture should be relatively simple and sturdily constructed. Pieces made of stainless steel have a high initial cost, but because of their durability they are preferred to enameled furniture.

The operating table (*1*) should be so

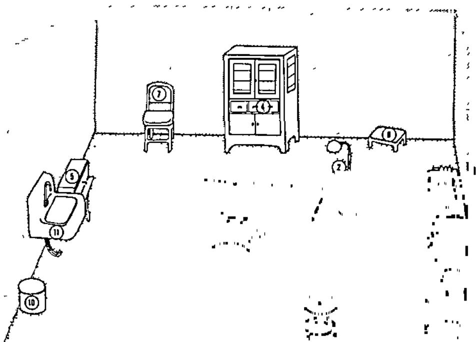


*Figure 7.* An arrangement of furniture in a minor surgical examining and operating room is shown

constructed that horizontal, Trendelenburg, rectal, gynecologic and chair positions can be readily obtained. A hydraulic lift is desirable but not essential.

The "goose-neck" floor lamp (*2*) is preferable to the more elaborate and expensive portable operating lights It is simple and inexpensive to operate and can be easily adjusted to provide a light source from any direction.

The treatment cabinet (*3*) is designed to permit maximum use of storage space. Solution bottles and supply jars can be placed against the rail around the back and sides, leaving a large work space in the center. Two large drawers and two separate compartments below provide ample storage space for supplies.

An upright cabinet (*4*) is needed for storing instruments and supplies. Adjustable glass shelves above will accommodate instrument and knife blade jars, needles and instruments that are not kept sterile. Three drawers provide ample space for storage of bandages, dressings, sterile syringes and other supplies. In the large storage compartment below, sterile packs and supplies such as bolt gauze, cotton and solutions are kept.

If an autoclave (*5*) is not available, the electric sterilizer must be large enough for sterilization of instruments as well as syringes, needles and glassware. The one shown has dimensions of 6 by 8 by 17 inches and will accommodate the largest instruments used in minor surgical procedures. The sterilizer can be placed on a small table or on brackets on the side of the treatment cabinet.

New office model autoclaves have a square chamber 8 by 8 by 16 inches and have proved satisfactory for sterilization of most instruments and supplies needed for minor surgical operations. After sterilization is completed, the door of the chamber can be opened slightly and packs dried thoroughly.

The Mayo type instrument stand and tray (*6*) is invaluable for operative procedures and for wound dressings. The stand is adjustable in height and designed so that the front legs can be placed under low operating tables and treatment cabinets.

A chair (*7*), footstool (*8*) and stool (*9*) are extremely useful, particularly when lesions of the extremities are treated. A waste receptacle (*10*) is required. Almost any type is satisfactory. The lavatory (*11*) should have a mixing faucet and foot or knee controls for convenience in carrying out the surgical scrub.

### SOLUTIONS AND OINTMENTS

The types of solutions and ointments needed in minor surgical practice will depend somewhat upon the general type of lesions treated and the extent of the procedures carried out on the ambulant patient. The solutions and ointments listed here are considered to be basic and to meet the essential requirements for office surgery. No attempt has been made to include the multitude of agents designed to promote wound healing when topically applied, since the extent to which they are employed depends largely on the enthusiasm of the physician for this type of therapy rather than on the actual effectiveness of the agents.

Physiologic saline solution, 50 cc. bottles
Distilled water, 50 cc. bottles
1 or 2, 1000 cc. flasks of physiologic saline solution
1 or 2, 1000 cc. flasks of 5 per cent dextrose in distilled water
Alcohol, 70 per cent
Zephiran chloride, 1:1000, aqueous solution
Tincture Mercresin or one of the other colored antiseptics
Bard-Parker germicide
Ether
Benzine
Tincture of green soap
Compound tincture of benzoin
Hydrogen peroxide
Procaine, 1 per cent
Ethyl chloride
Epinephrine, 1:1000 solution
Aromatic spirits of ammonia
Silver nitrate applicators
Silver nitrate, 10 per cent solution
Collodion
Formalin, 10 per cent
Lubricating jelly
Petrolatum
Lanolin
Iodoform gauze

Physiologic saline and distilled water are used as diluents and are put up in 50 and 100 cc. rubber-stoppered bottles from which fluid can be removed with syringe and needle. One thousand cc. flasks of physiologic saline and 5 per cent dextrose in distilled water should be available for use in an emergency when parenteral fluids are required. Procaine solution should be purchased already prepared since it is difficult to sterilize. It can be kept in bottles with screw-on caps, from which the solution can be poured into a medicine glass when the instrument tray is set up, or rubber-stoppered bottles may be used and the solution withdrawn directly into a syringe as it is needed. On the top of the treatment cabinet 8-ounce bottles containing alcohol, hydrogen peroxide, benzine, tincture of green soap and tincture of Mercresin can be placed against the railing at the sides and back, since these items are the ones most commonly employed in wound dressings. Alcohol-soaked cotton pledgets should be kept in a wide-mouthed, covered jar for use in cleaning the skin prior to hypodermic injections. Although petrolatum gauze can be purchased in sterile packets, it can be prepared very simply. Six- or 7-inch lengths of fine mesh gauze roller bandage are placed in a small catheter tray, and melted white petrolatum is poured over the gauze. The tray is covered, and when autoclaved the gauze is ready for use.

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1. Meade, W. H., and Ochsner, A.: The relative value of catgut, silk, linen and cotton as suture materials. Surgery, 7:485–514, 1940.
2. Alexander, E. L.: Operating Room Technique. St. Louis, C. V. Mosby Co., 1949.

*Chapter 2*

# Surgical Considerations

*By Oscar Creech, Jr.*

## CONTRAINDICATIONS TO MINOR *SURGICAL PROCEDURES*

Minor surgery generally connotes surgical therapy of lesions offering little or no immediate or potential threat to life, which may be treated with the patient on an ambulant status. Care must be exercised, however, in the selection and preparation of patients. Patients with diabetes, blood dyscrasias or severe heart disease are poor subjects for office surgery and probably should be operated upon in the hospital regardless of the extent of the surgical procedure. If a patient must remain in bed for one or two days after a minor surgical procedure, he should be hospitalized for the operation if nursing care at home is not available.

Lesions that may be malignant and require wide excision are best treated in the hospital, where an immediate histologic diagnosis can be made. Similarly, if the extent of a lesion cannot be determined before operation, the patient should not be operated upon in the office.

## PREOPERATIVE CARE

Because of their minor nature, the surgeon is often inclined to minimize the significance of these relatively simple procedures, with the result that the patient is poorly informed about the condition to be treated and the surgical procedure to be undertaken. It is extremely important that the patient be fully aware of the need for and scope of the operation and the type of anesthetic to be used. If postoperative disability is likely, the patient should be prepared for it. If this has been done and the patient appears reluctant to submit to the suggested operation, it should be postponed. Operation on the reluctant patient is singularly unrewarding, and in view of the minor nature of many of these lesions, it is better to defer therapy when the patient is not convinced of its necessity.

Whenever possible, the operative procedure should be scheduled in advance, so that someone can accompany the patient to and from the office or clinic.

The patient should be instructed to wear clothing which will permit wide exposure of the part or which can be easily removed and easily put on after the operation is completed If the lesion is on the face, men should be instructed to shave closely one or two hours before the operation is scheduled. It is well to have the patient omit the meal immediately preceding operation Children should fast for at least 6 hours, or longer if a general anesthetic is to be employed. If the anesthetic is procaine, one of the barbiturates should be given about one hour prior to anesthetization.

## CONDUCT OF OPERATION

In view of the circumstances under which most minor surgical operations are carried out, careful prior planning is of first importance. Lacking the services of an anesthetist and often of an assistant, and frequently working with a patient who is inadequately sedated, the surgeon must make certain that the instruments and supplies needed for the procedure are properly prepared and at hand so that the operation may be carried out expeditiously. When one is forced to work alone, this requires considerable ingenuity.

The patient's position during the operation should afford maximum exposure and accessibility of the part and should be capable of being maintained comfortably. A foam rubber mattress on the operating table will add immeasurably to the patient's comfort. A useful support for the upper extremity is a board 6 inches (15 cm.) in width and 3 feet (90 cm.) in length, anchored by placing one end between mattress and table for the extremity.

With the part properly positioned and adequately exposed, an area considerably larger than the operative field should be shaved. If dry shaving has been done, the cut hairs can be easily removed by repeatedly applying a strip of adhesive tape to the area, adhesive surface down. After the area has been shaved, it is cleaned by friction sponging several times with ether-soaked sponges, then painted with one of the colored antiseptic tinctures. The colored solution is preferable because it outlines the area that has been prepared. This solution should not be allowed to run down onto parts which are covered, as burns may result. One of the detergent preparations containing hexachlorophene may also be used to prepare the operative site. The area should be washed for 5 minutes with the detergent solution, to which water has been added. The part is then rinsed with water. No antiseptic tinctures should be applied after use of these agents.

For repair of traumatic wounds in children, it is best to postpone shaving and cleansing of the wound until the area has been infiltrated with a local anesthetic. A 1 cm. area away from the wound is painted with antiseptic tincture and in this area the initial skin wheal is made. With a 3-inch, 22-gauge needle the entire field can be anesthetized through this site. In this way, the patient is spared considerable pain and

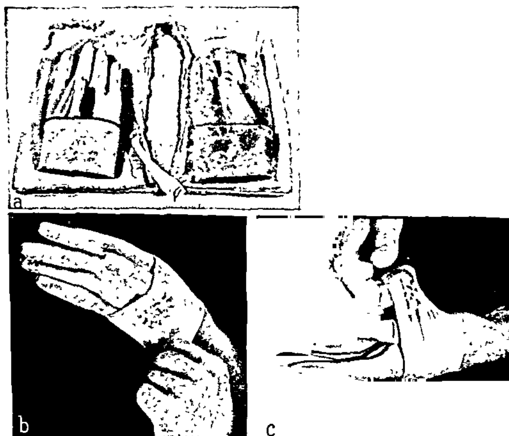



*Figure 8* *a*, The muslin envelope in which the gloves were autoclaved has been opened and the gloves and powder lifted out of the compartment with pickup forceps and placed on top of the envelope. *b*, After the hands have been dusted with powder, the right glove is put on by grasping the turned-back cuff with the fingers of the left hand *c*. The left glove is then picked up by slipping the gloved fingers of the right hand beneath the turned-back cuff.

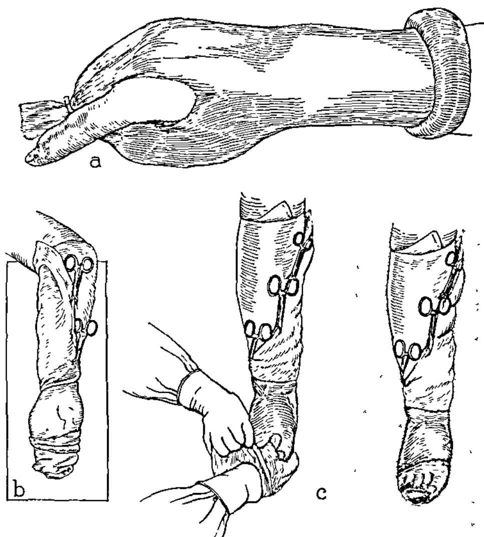



*Figure 9* Methods of draping an extremity for surgical procedures *a*, After the fingers and hand have been scrubbed with soap and water and sponged with ether and antiseptic tincture, the hand and lower third of the forearm are encased in a sterile stockinet roll A small opening is then made *in the stockinet over the involved finger, and that finger is pulled through the opening and* exposed *b*, For operations on the hand, the forearm and hands are surgically cleansed, and the forearm is draped with sterile towels A sterile rubber glove is then inverted over the fingers, leaving only the dorsum and palmar aspect of the hand exposed. *c*, A method of draping the lower extremity for operation The leg and foot are surgically cleansed, and the leg is wrapped in a sterile towel. A second rubber glove is placed over the right hand of the operator, the toes of the foot are grasped, and the glove is turned back over the toes, leaving exposed the dorsum and plantar surface of the foot. If the toes are to be operated upon, the glove can simply be omitted

discomfort, and the surgeon avoids the unpleasantness of a noisy, uncooperative patient.

Under ordinary circumstances, it will not be necessary for the surgeon to wear a sterile gown, but a short-sleeved coat or plastic apron should be worn to protect his clothing. A surgeon's cap and mask are mandatory. The mask should cover both the nose and mouth.

The surgical scrub should be carried out as scrupulously as if preparing for a major operation. The hands and forearms are washed in soap and water, and the fingernails are cleaned. Then the hands should be vigorously scrubbed for 10 minutes with soap and water, rinsed thoroughly, rubbed with a sponge soaked in a 70 per cent alcoholic solution and dried on a sterile towel. If one of the detergent agents containing hexachlorophene is used, the surgical scrub requires only 5 minutes, 2½ minutes for each hand. When these agents are used, it is important to add small amounts of water frequently so that loose detritus will be removed. After the scrub, the hands and forearms are rinsed thor-

oughly in water and dried directly with a sterile towel. The use of alcohol is contraindicated since it removes the film of hexachlorophene left on the surface of the skin. It should be kept in mind that, after scrubbing, the hands are not sterile but only surgically clean, and gloves must be put on in such a way that their outer surface is not contaminated (Fig. 8).

The sterile field is completed by placing drapes about the operative site, either towels or muslin sheets (Fig. 1). Towels permit exposure of a larger area and can be placed to conform to the shape of the operative area, but they must be anchored securely with towel forceps.

Special care is required for preparation of the hands and feet for operation. Nails should be cut and cleaned and the part scrubbed with soap and water for 10 minutes, friction-sponged several times with ether, and then painted well beyond the area of operation with a colored antiseptic solution. The various methods of draping the extremities are shown in Figure 9.

Figure 10 shows an instrument tray set up for a minor surgical procedure. For most operations, the basic minor surgical set will be adequate, and any additional items needed can be sterilized by boiling or autoclaving and added to the set at the time of operation.

The procedures to be described are helpful in establishing a routine to follow in preparing for a minor surgical operation.

### With Assistance

The patient is placed in position for operation, and the part to be operated upon is exposed. The part is shaved widely and scrubbed vigorously with ether. The surgeon then carries out the surgical scrub and puts on sterile gloves. The assistant opens the instrument pack and package of sterile towels, and the surgeon then sets up the instrument tray. Antiseptic solution and the local anesthetic agents are poured into medicine glasses by the unsterile assistant. Knife blades, scissors, sponges, syringes and needles are placed on the instrument tray by the assistant with sterile pick-up forceps. With sterile cotton applicators or sterile sponges on a hemostat, the operative field is painted with antiseptic solution and the applicator or hemostat discarded. The field is then draped.

### Without Assistance

The patient is placed in position and the part to be operated upon is exposed,

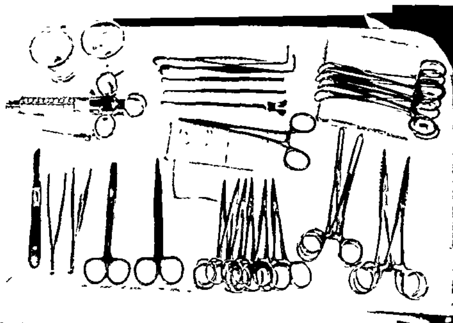


*Figure 10* The basic minor surgical instrument set is arranged on the Mayo tray for operation.

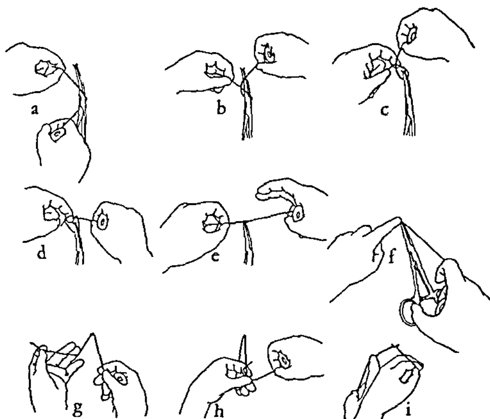



*Figure 11* A method of ligating bleeding vessels without assistance.

shaved and cleaned with ether. Before scrubbing, the surgeon drapes the instrument tray with sterile towels, using sterile pick-up forceps. Articles such as sponges, syringes, needles, cotton applicators, towels and an operating drape are placed *on the instrument tray*. The instrument pack is then opened, and the two medicine glasses are removed with pick-up forceps and placed on the instrument tray. The antiseptic solution and local anesthetic agent are poured into the medicine glasses. The glove pack is then opened. Surgical scrub is then carried out, and sterile gloves are put on. The instruments are removed from the instrument pack. The operative area is painted with antiseptic solution and is draped. It will be noted that preparations have been carried out in such a manner that once the surgeon has completed the scrub and has put on gloves, it is not necessary to break scrub to obtain needed items.

If local infiltration anesthetic is used, it is well to mark the line of incision over the lesion with a needle scratch prior to injection of the anesthetic agent, as the position of the lesion with relation to the skin surface is often obscured by the infiltrated anesthetic solution.

Retraction may present a problem if the surgeon is working alone. A small self-retaining mastoid retractor is useful, *particularly if the teeth have been filed* to a point. Sutures placed but not tied in the subcutaneous tissue on both sides of the wound and weighted with hemostats may provide sufficient retraction If an assistant is available, the rake retractor or skin hook is generally employed.

Hemostasis is rarely a problem in the treatment of minor surgical conditions. During the operation, bleeding can be controlled by the use of procaine, to which a solution of 1:1000 epinephrine has been added in the proportion of 2 drops of epinephrine to each ounce of anesthetic agent. However, this solution should not be employed in patients with hypertension or other manifestations of cardiovascular disease. If the wound is small, pressure exerted with the finger tips along the margins of the wound, or lateral retraction of the wound edges, will control bleeding until the wound is

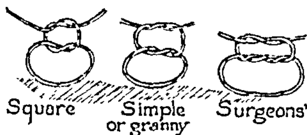



*Figure 12.* The types of surgical knots commonly used.

closed and a pressure dressing is applied. If bleeding vessels must be ligated to secure hemostasis, only the tip of the vessel should be grasped with the tip of the hemostat. No. 60 or 70 cotton will generally be satisfactory for hemostatic sutures and ligatures.

A surgeon operating without assistance may have to ligate bleeding vessels alone. This can be accomplished by the following technique (Fig. 11). After the first tie is made by either the one- or two-hand method, tension is maintained on the two ends of the suture. In the hand nearest the handle of the hemostat, the suture is held in the palm by pressure of the middle or ring finger; this leaves the index finger and thumb free to disengage the hemostat. With the hemostat removed, the square knot is completed.

During operations on the hands and feet, it may be desirable to use a tourniquet to obtain a bloodless field. The

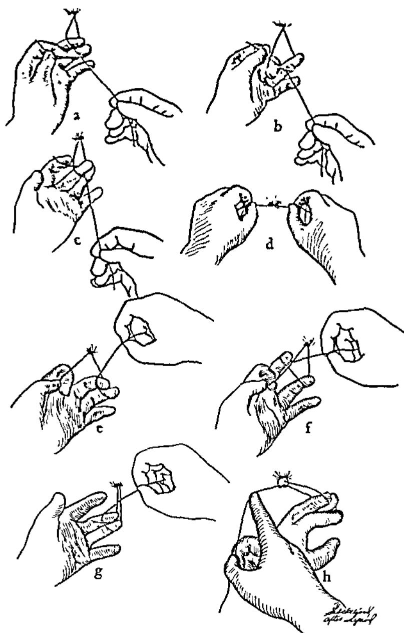



*Figure 13.* The one-hand method used for knot tying

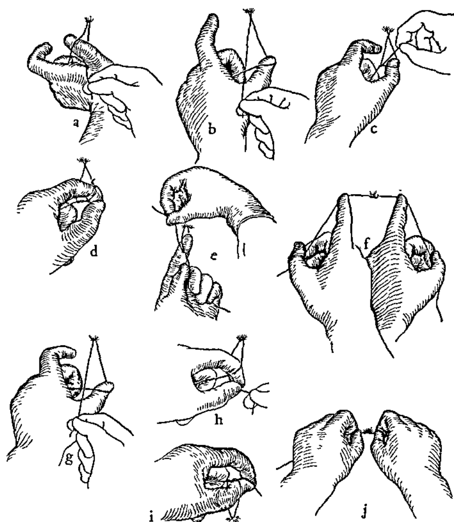



*Figure 14.* The two-hand method used for knot tying.

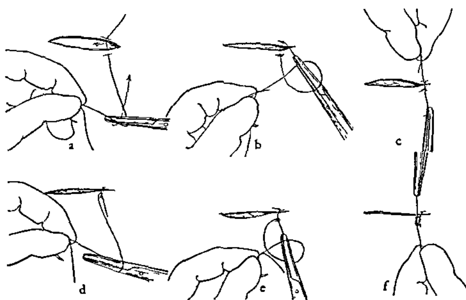



*Figure 15.* The steps employed in tying a knot with an instrument.

extremity is elevated for one to two minutes to increase venous drainage, and a sphygmomanometer cuff is then applied above the elbow or just below the knee. The cuff is inflated rapidly to a pressure of 200 to 250 mm. Hg. This pressure can be maintained for 45 minutes. If more time is required for the operation, the cuff can be deflated for a short time, then reinflated.

No. 40 cotton is adequate for both deep and cutaneous sutures except for wounds about the face or exposed parts where a good cosmetic result is particularly desirable. Here fine dermal sutures should be employed.

In general, sutures and ligatures should be tied by making a square knot (Fig. 12). This can be accomplished by either the one-hand (Fig. 13) or two-hand method (Fig. 14) or by using a needle holder or hemostat (Fig. 15). In general, the one-hand method is faster. However, when the tie is made under tension, the first loop of the square knot tends to slip while the second loop is being made. Under these circumstances, the two-hand method is preferred. The method of using a hemostat or needle holder in tying sutures is extremely useful in minor surgical procedures, as it permits placement of several sutures with a single 18-inch length of suture material. This requires less threading of needles and permits more economical use of the suture material.

Buried sutures of nonabsorbable material should be interrupted (never continuous) and should be cut on the knot. The sutures should be so placed that all dead space is eliminated when the wound is closed, and surgical wounds should be so planned that they can be closed without tension. To eliminate dead space when placing closing sutures,

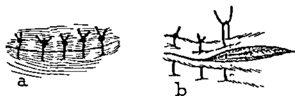



*Figure 16* Two types of skin sutures are shown: *a*, simple interrupted, *b*, vertical mattress.

the needle should first grasp one lateral wall, then the base, and finally the opposite lateral wall of the wound.

Simple, interrupted sutures are satisfactory for skin closure in most cases. The sutures should be tied so that the knots lie to one side of the incision and the ends of the sutures are separated and directed away from the incision. This makes removal of sutures easier and less discomforting to the patient. If the wound edges do not come together properly or there is oozing from the skin edges, interrupted vertical mattress sutures should be used (Fig. 16).

Wound dressing after operation will vary somewhat with the type and location of the wound. However, for most surgical wounds, the 4 by 4 gauze squares will make a satisfactory dressing.

### POSTOPERATIVE CARE

Postoperative care must be as carefully planned and carried out for ambulatory patients as it is for hospital patients. In many instances, the patient will require more detailed instructions regarding care of a minor operative wound than would be necessary after a major operation when hospital personnel are available to care for the patient. The surgeon should try to anticipate complications and should instruct the patient in the proper precautionary measures to be taken to avoid them.

The patient should be kept in the office or clinic until sufficiently recovered from the anesthetic and operation to return home safely. Rarely should the patient be permitted to leave unaccompanied.

Local anesthesia lasts about two hours, after which the discomfort produced by the operative wound will appear. Acetylsalicylic acid in a 10-grain dose given at the end of the operation will usually be sufficient to control the early postoperative symptoms. For severe pain, 0.5 grain of codeine may be added. These analgesics may be repeated at intervals of three to four hours. In more extensive operations, 50 to 75 mg. of Demerol may be given every few hours as required. If a pressure dressing has been applied

to control bleeding from the operative wound after closure, the patient should be instructed to rest the part in an elevated position and to expect some oozing from the wound for several hours. In addition, the patient must be prepared for the large amount of bloody, purulent drainage which often occurs after incision and drainage of a large abscess.

If hot moist dressings are to be used at home, specific instructions must be given with regard to type of solution to be used and length of time dressings are to be applied. If dressings are to be changed at home, the patient should be told the type of dressing to use and where it can be purchased.

In many instances, antimicrobial therapy must be employed after operation. Plans for such therapy should be made before the patient leaves the office. Because of the convenience, one of the agents that can be administered orally is preferred.

Finally, the patient should be instructed to call the surgeon at once if postoperative symptoms become severe or if any unusual symptom appears.

Chapter 3

# Dressings and Bandages

*By Oscar Creech, Jr.*

### TYPES

In general, dressings and bandages may be classified into three groups: those applied primarily for *wound covering,* those that *immobilize and support* the part, and those that have special *therapeutic* value. A wound covering protects a surgical wound until healing is complete, or it absorbs the drainage from a discharging wound. Dressings which are applied for immobilization and support are commonly used for wounds and injuries of extremities. Hot fomentations, the pressure boot and dressings in which some agent has been incorporated because of its medicative properties comprise the category of special therapeutic dressings.

### TECHNICAL APPLICATION

Proficiency in applying wound dressings, bandages and splints is often indicative of general technical proficiency. To the patient, a carefully and neatly dressed wound is more likely to be a mark of competence than is the well executed surgical procedure. Care should be taken that bandages and dressings are properly applied in order that they may be effective, be comfortable to the patient and remain in place for the period of time desired. It is distressing to the patient to find that the dressing so neatly applied in the doctor's office has fallen apart by the time he reaches home.

### Wound Covering

A clean surgical wound is covered after operation with several gauze

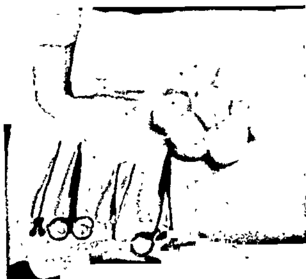


*Figure 17.* The dressing tray is prepared for wound dressing.

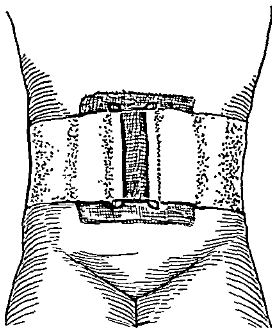
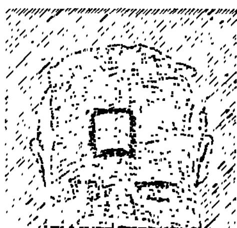


*Figure 18.* Modified "Montgomery straps" A tongue depressor is divided lengthwise into two pieces, each of which is then fastened to the strips of adhesive by folding the ends of the tape over the tongue depressor. A dressing is applied to the wound, and the straps are placed over it and held together at each end by rubber bands.



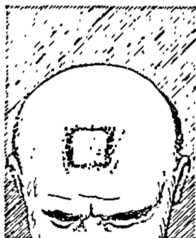


*Figure 19* A collodion scalp dressing The wound is covered by a gauze square which is, in turn, covered by two layers of gauze (obtained by unfolding a 4 by 4 gauze square) Collodion is applied to the scalp through the outer gauze covering at the four sides of the wound dressing. After the collodion has dried, the outer gauze is trimmed away with scissors.



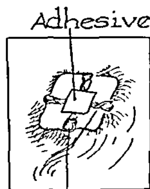




*Figure 20.* This type of scalp dressing is particularly useful for women. The wound is covered with a gauze square, and several strands of hair on each of the four sides of the dressing are then twisted and brought across to the center of the dressing and secured with a small piece of adhesive tape

squares. The dressing should not be bulky and should be applied with a *slight amount of pressure.* If hemostasis has been incomplete or if it has been impossible to eliminate dead space in the wound, the thickness of the dressing over the line of incision should be increased and the dressing applied with a greater amount of pressure. The wound covering is secured with adhesive tape or one of the other bandaging materials. If the part to which the adhesive is to be applied is hairy, it should be shaved and the sites of contact of the adhesive with the skin rubbed lightly with an ether-soaked sponge to dry the skin.

*The dressing of wounds and removal* of sutures should be accomplished under conditions of relative sterility. The Mayo tray is draped with a sterile towel, and several sterile gauze squares are placed on the tray. With pick-up forceps, the necessary instruments, i.e., dressing forceps, hemostats, suture scissors, probe, etc., are removed from the instrument jar and either handed to the surgeon or placed on the tray in such a way that they can be picked up without contami-

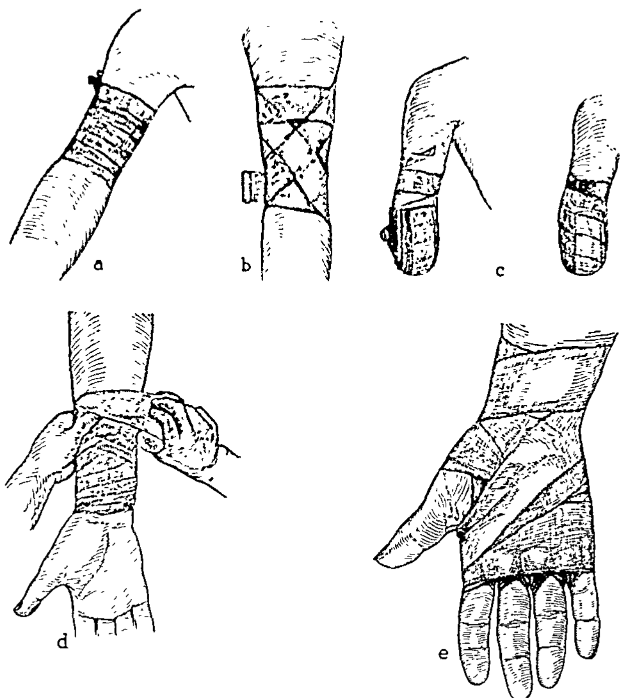



*Figure 21. a, The Circular Bandage*· The bandage is fixed by two or three turns about the part. It is then advanced up or down the part by successive circular turns, each of which overlaps the one preceding by 0.5 inch (1 3 cm) to 1 inch (2.5 cm), depending upon the width of the bandage.

*b, The Figure-of-Eight Bandage.* Several circular turns are made. The bandage is then carried obliquely across the part above the joint and another circular turn taken, thus completing a figure-of-eight This process is repeated, overlapping each turn, until the part is covered.

*c, The Recurrent Bandage* Several circular turns are made about the extremity. While an assistant fixes the bandage, its direction is changed 90 degrees, and it is carried back and forth across the end of the stump until the stump is covered. Several more circular turns are then made to complete the bandage. This type of bandage may also be used for head dressings

*d, The Spiral Reverse Bandage.* The bandage is fixed by two or three circular turns. Then on each succeeding turn, the roll is rotated counterclockwise 180 degrees as the bandage is advanced along the extremity.

*e, Hand Bandage* This bandage represents a combination of the various types

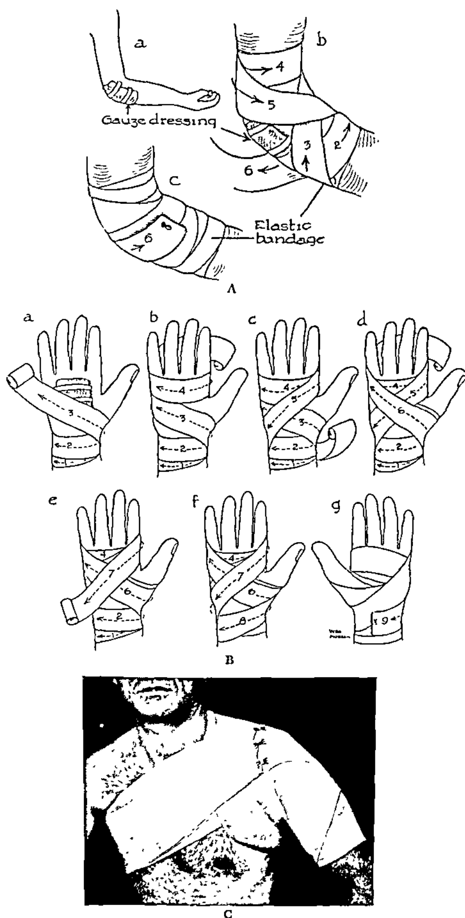
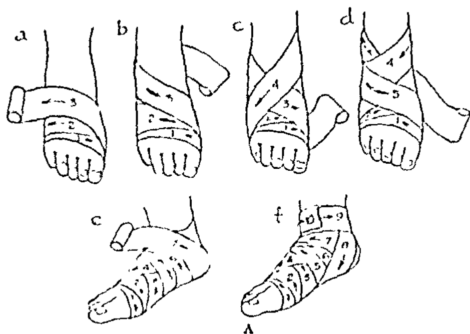
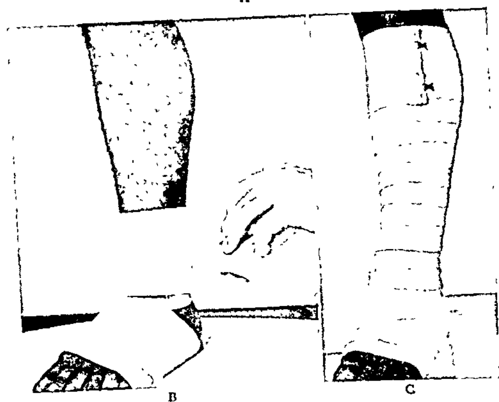
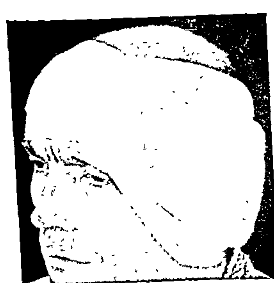



*Figure 22.* The elastic bandage is used in applying dressings to the elbow (*A*), hand (*B*) and axilla (*C*).


a
b
c
d
e
f
A


B
C


D


E

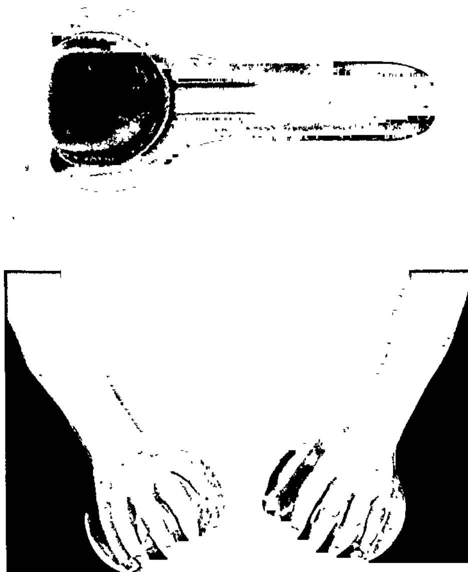


*Figure 24.* The Allen-Mason universal hand splint.

nating the part of the instrument to be applied to the wound or the other items on the tray (Fig. 17). The external layer of the dressing is lifted off by hand, and thereafter the dressing and wound are touched only with the sterile instruments and supplies. With a dressing forceps and hemostat, the corners of a gauze square are folded into the center. It is then picked up with a hemostat and saturated with ether, alcohol, or some other cleansing or antiseptic agent, and the skin about the wound is cleansed. If sutures are to be removed, the incision is painted with alcohol or one of the colored antiseptic tinctures.

In removal of sutures, they should be cut close to the skin and extracted by pulling the free end towards the line of incision to avoid separating the wound edges.

Draining wounds require frequent dressings. Care must be taken to prevent maceration of the skin surrounding the wound and irritation from repeated application of adhesive. Usually, absorbent cotton is incorporated in the gauze dressing as a filler to increase absorption of the discharging material. If adhesive tape is used to secure the dressing, it should be cut at the edge of the gauze when the dressing is changed, and a new tape should be placed over the old to avoid repeated applications of adhesive to the skin. For chronically draining wounds, Montgomery straps are particu-

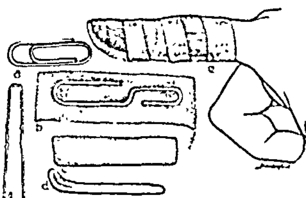


*Figure 25.* A bandage for use on fingers. With a hairpin or paper clip incorporated into the dressing, a degree of immobilization is achieved.

larly useful, especially if wounds are dressed at home (Fig. 18).

In removal of adhesive, the quick jerk may remove a layer of the epidermis in addition to the tape. Care should be taken to avoid this, especially if the adhesive has been in place for several days. A cotton pledget soaked in benzine, ether or one of the proprietary "adhesive removers" applied to the edges of the tape will make removal easier and decrease discomfort to the patient.

On the face or scalp, small wound coverings can be secured with collodion

*Figure 26* The commercial elastic adhesive bandages for the fingers and hand (Photograph courtesy of Duke Laboratories, Inc.)

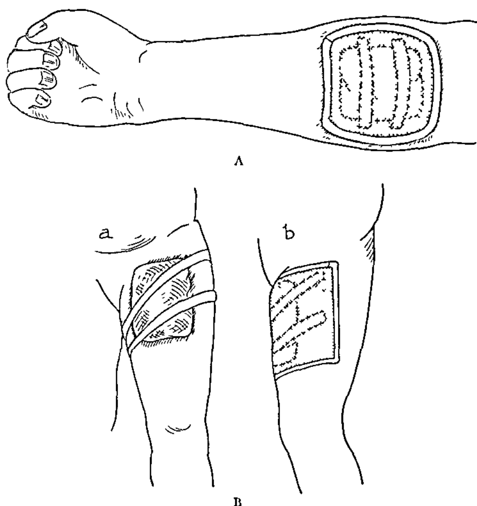



*Figure 27* Elastic adhesive bandage makes a satisfactory covering for a gauze dressing of the forearm (*A*) and the thigh (*B*) Because of a tendency to roll, the free edges should be covered with a narrow strip of nonelastic adhesive tape.

(Fig. 19), or the hair may be fixed over the scalp dressing with adhesive tape (Fig. 20).[1]

The gauze roller bandage, properly applied, is an effective and attractive method of securing a wound dressing. Separately or in combination, the circular, recurrent, spiral-reverse and figure-of-eight bandages can be utilized in bandaging almost any part of the body (Fig. 21).

IMMOBILIZATION AND SUPPORT

The elastic bandage is also widely used as a supportive and compressive bandage because of its versatility and ease of application (Figs. 22 and 23). In addition, it offers a degree of immobilization of the part. Two types of elastic bandages are available. The first contains no rubber but derives its stretch from the weave of the cloth. It has little advantage over the simple muslin bandage. The second type contains rubber and has a high degree of resiliency, which it retains after it is laundered. It can be snugly applied with less danger of constriction than a nonelastic bandage.

Application should begin at the distal end of the extremity proximal to the phalanges and proceed proximally in a circular fashion. About the ankle, knee, elbow and wrist it should be applied as a figure-of-eight to permit more complete conformity to the part during motion (Figs 22 and 23). Each succeeding turn should overlap the one preceding by approximately 0.5 to 0 75 inches

If the part is to be completely immobilized, splints should be incorporated into the dressing. Basswood splints are inexpensive and, when padded with cotton and wrapped with gauze roller bandage, form a comfortable splint for

use in dressing soft-tissue wounds of the hands and forearms. As it is difficult to maintain the hand in a functional position with this type splint, it should not be used for the treatment of fractures or for any condition requiring prolonged immobilization. For this purpose, plaster of paris or the "Universal Hand Splint" described by Allen and Mason[2] should be used (Fig. 24). For lesions of the distal phalanges of the fingers, a hairpin or paper clip can be incorporated in the bandage in such a way as to immobilize the distal interphalangeal joint[3] (Fig. 25). Plastic or elastic adhesive bandages are ideally suited for covering minor surgical wounds. Being water repellent, they require less frequent changing, and their elasticity affords a degree of pressure and immobilization of the part which is not obtained with nonelastic adhesive (Figs. 26, 27 and 28).

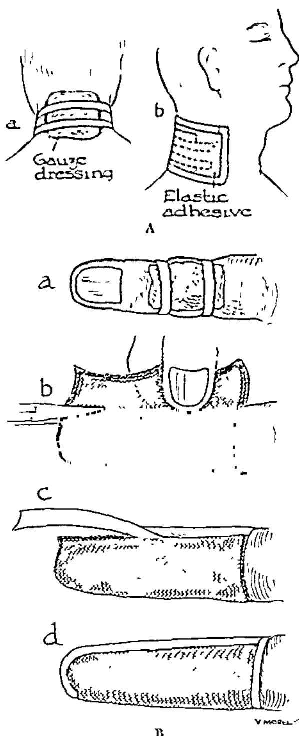



*Figure 28.* Elastic adhesive bandages may also be effectively used for dressings on the neck (*A*) The use of this material eliminates the need for encircling bandages. An immobilizing covering for a finger dressing may also be prepared from elastic adhesive (*B*).

### Special Therapeutic Dressings

*Although Unna's paste boot is still* widely used, the length of time necessary for preparation of the paste and application of the bandage constitutes a distinct disadvantage. The commercial medicated (zinc-gelatin) gauze roller bandage can be applied easily to the foot and leg in a circular fashion and covered with an elastic adhesive for an effective compression boot which may remain in place for as long as two weeks (Fig. 29). The zinc-gelatin mixture remains moist and viscous and, unlike Unna's paste, does not harden.[5]

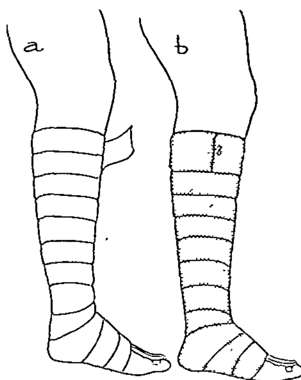


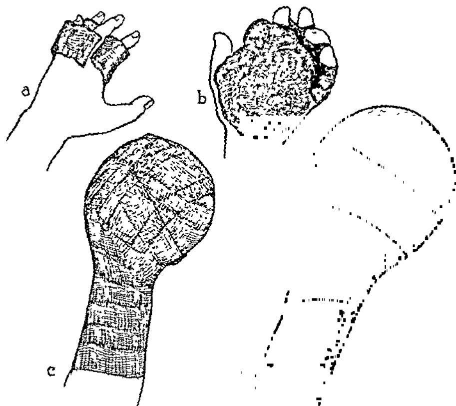

*Figure 29.* Application of a zinc-gelatin boot.

The voluminous pressure or occlusive dressing is useful in the treatment of burns or severe infections of the extremities (Fig. 30). For burns, plain fine mesh gauze, petrolatum gauze or rayon is placed directly on the burn, over which a pressure dressing is applied.[6, 7] For infections of the extremities, this type of dressing provides relative immobility of the part. With a layer of cellophane beneath the outer elastic bandage and one or two catheters incorporated into the dressing, heat can be easily applied to the part by moistening the dressing with warm saline or other solution through the catheters. To prevent maceration, this moist dressing should be removed at the end of 24 hours and the part dried thoroughly before the dressing is reapplied.

One of the most effective and simplest methods of applying moist heat to an inflamed part is by use of moist compresses and an electric heating pad. Ordinary bath towels are wet in tap water warmed to the point that it is tolerated on the inner side of the elbow. These are wrapped around the involved extremity, or simply applied to the part if other than an extremity, then covered with a sheet of wax paper or plastic of the type used for kitchen purposes (Saran wrap).* An electric heating pad is then placed over the plastic.

A method of applying moist heat to a part without resorting to an external heat source has been described.[8] The involved extremity is placed into an insulated sleeve made of Fiberglas, and heat lost from the skin by radiation, convection and conduction heats the surrounding investments. There is no need to apply heat from an external source, as with this method the temperature of the skin can be raised to a point one or two degrees higher than the temperature ordinarily achieved with the hot poultice (Fig. 31).

* Made by Dow Chemical Company, Medland, Michigan




compress dressings being used. This is then wrapped snugly with gauze roller bandage. d, The dressing is finally covered with an elastic bandage.

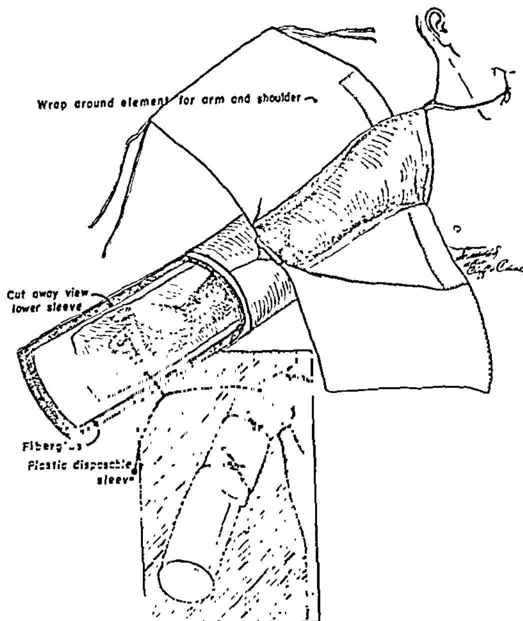



*Figure 31.* A Fiberglas-plastic envelope for the application of moist heat.

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*Chapter 4*

# Anesthesia and Resuscitation

*By John Adriani*

## INTRODUCTION

Some anesthesiologists dislike the term "general anesthesia" because it lacks specificity. Nevertheless, it is a useful term because it denotes that unconsciousness accompanies the relief of pain necessary to perform a surgical procedure. In most instances one may distinguish between minor and major surgery; however, it is almost impossible to make a distinction between a "minor" and a "major" general anesthetic. Death may occur as readily during brief, light general anesthesia for a simple procedure as during a long, deep one for more formidable operations Overdosage, asphyxia from obstruction or aspiration, and numerous technical complications are ever present possibilities during administration of any type of general anesthetic. The hazard attending even the simplest procedures is thus increased many fold. It is advisable to avoid general anesthetics for minor surgical procedures whenever possible.

The term "local anesthesia" immediately imparts the idea that relief of pain is obtained without loss of consciousness. The term "conduction anesthesia" is preferred by some. Most anesthesiologists accept the term "regional anesthesia." The latter type is subdivided according to the site of injection of the drug used to interrupt conduction of nervous impulses. For instance, if the drug is placed in the subarachnoid space, it is called spinal anesthesia; in the peridural space, peridural block; along a nerve trunk, nerve block, and so on.

## GENERAL ANESTHESIA

Irrespective of the hazards involved, certain simple surgical procedures cannot be performed without general anesthesia. For example, infected areas are incised with difficulty if a general anesthetic is not employed. Moreover, many procedures in the region of the head and neck cannot be performed without general anesthesia. Infants, children and extremely apprehensive or psychotic patients are uncooperative and cannot be operated upon without general anesthesia.

The three requisites of a satisfactory general anesthetic are *relief of pain, muscle relaxation* and *unconsciousness.* Muscle relaxation is seldom necessary for minor surgical procedures. Deep anesthesia is ordinarily needed to secure relaxation, and, therefore, such anesthesia transforms a simple surgical procedure into a major one.

General anesthesia is classified according to the route of administration of the drug selected. Three important types are *inhalation, intravenous* and *rectal.* There are no entirely satisfactory drugs for yielding surgical anesthesia by *oral* or *intramuscular* use. The practice of attempting surgical manipulations by administration of a "quarter of morphine" is barbaric and is reminiscent of attempts at securing anesthesia prior to the discovery of ether. Inhalation anesthetics are either gases or highly volatile liquids. An inhalation anesthetic suitable for minor surgery should possess the properties of rapid induction and recovery. The drug should be nonirritating, pleasant and devoid of untoward reactions. The three gases currently available for anesthetization by inhalation—cyclopropane, nitrous oxide and ethylene—are

all suitable for minor surgical procedures. Six liquids are available: ether, vinylether (Vinethene), chloroform, ethyl chloride, trichlorethylene and fluothane. Of these, vinyl ether, fluothane and trichlorethylene are useful for the ambulatory patient. They can all be used for the ambulatory patient in combination with nitrous oxide.

Nonvolatile drugs are used for rectal and intravenous anesthesia. Of these, the ultrashort-acting barbiturates are the most useful, such as thiopental and thiamylal.

### Inhalation

*Cyclopropane.* Cyclopropane is a pleasant, rapidly acting hydrocarbon, sufficiently potent not only to relieve pain, but also to produce muscle relaxation. Light anesthesia is secured with 15 per cent in the alveoli, deep anesthesia with 25 per cent. All general anesthetics cause respiratory failure if administered to the point of overdosage. The margin of safety with cyclopropane is wide, however, 40 per cent being necessary to produce respiratory failure. At all times adequate tension of oxygen in the inhaled mixture is permitted. Cyclopropane is most suitable for simple surgical procedures because it is pleasant, nonirritating, and may be used in patients of all ages. Depth is easily and quickly varied. Induction is rapid, requiring 2 to 3 minutes. Recovery, likewise, is rapid since almost complete elimination requires less than 10 minutes. Patients are fully recovered within a short time and may be ambulatory shortly after operation, if necessary. Postanesthetic drowsiness or somnolence is not a problem.

Although excellent for minor surgery, cyclopropane possesses certain disadvantages. Since it is inflammable, it should be administered only in hospitals where proper safeguards for prevention of fires and explosions have been taken. Postoperative vomiting and nausea are prevalent, irrespective of sedation of the patient, duration of the anesthesia and skill of the anesthesiologist. Moreover, cyclopropane increases the irritability of the cardiac automatic tissues. Spontaneous arrhythmias may occur, usually if anesthesia is deep or prolonged. However, this is seldom the case in minor surgical procedures so that cardiac irregularities are rarely a problem. Nevertheless, it is advisable in most instances to employ another anesthetic for patients with any type of well defined heart disease. Epinephrine administered simultaneously with cyclopropane may cause severe disturbances in cardiac rhythm, usually ventricular in origin. Ventricular tachycardia and even ventricular fibrillation are likely possibilities.

*Nitrous Oxide.* For many years, nitrous oxide has been accepted as the general anesthetic of choice for minor surgical procedures. Although a potent analgesic, it is a weak anesthetic. Surgical anesthesia is secured with difficulty in most cases unless the alveolar concentration is 80 per cent or even more (600 mm. Hg). The alveolar oxygen tension is often reduced beyond the limits of safety in attempts to secure surgical anesthesia with nitrous oxide alone. Overdosage is impossible because of the mild potency of the drug. Death from asphyxia, on the other hand, is a strong possibility and not a rarity.

Nitrous oxide is recommended as the sole agent only in the few instances in which it may be administered in nonasphyxial concentrations or for analgesia. If nitrous oxide is combined with other anesthetic or narcotic substances, it may be administered in nonasphyxial concentrations. In fact, this is the only way it may be administered with any degree of safety to the majority of patients. There are two ways to accomplish this: (1) fortify the drug with another potent inhalation anesthetic, such as ether, fluothane, trichlorethylene or vinyl ether; (2) combine it with some hypnotic or basal narcotic, such as morphine and scopolamine, the ultrashort-acting barbiturates (*Pentothal, Surital, Evipal*) or Avertin. Attempts to use nitrous oxide alone in resistant subjects are followed by incomplete anesthesia, struggling, excitement, severe cyanosis, elevation in blood pressure and other objectionable and deleterious effects

Sweating, laughing, hysterical manifestations and fecal incontinence are possible postanesthetic complications. Protracted nausea, retching and vomiting or sweating in the postanesthetic period are evidences that anoxia existed during administration.

Nitrous oxide is rapid in its action, anesthesia being induced within 2 or 3 minutes. Recovery, likewise, is rapid, requiring 2 or 3 minutes The gas is pleasant to inhale and nonirritating. It is also noninflammable and, therefore, should be employed in places where a fire hazard cannot be excluded. In adults, the preanesthetic administration of morphine (15 mg. for robust individuals and 10 mg for those of slight stature) and scopolamine (0 4 mg) intramuscularly is necessary unless narcosis with an ultrashort-acting barbiturate is contemplated. For optimal effects this medication must be given 1 to 1½ hours prior to anesthetization In emergencies the slow intravenous administration (over 3 minutes) 10 minutes prior to induction of anesthesia will yield satisfactory results. There is no factual basis for the contention that Negroes do not tolerate nitrous oxide

*Ethylene.* Ethylene is a gaseous hydrocarbon, possessing an anesthetic potency somewhat greater than that of nitrous oxide. It is used in exactly the same manner and for the same purposes as nitrous oxide. It is not as well known as nitrous oxide and not as widely used because of its inflammability. It is somewhat safer, though, because of its greater potency. Compared with nitrous oxide an average concentration of 5 per cent less in the alveoli yields surgical anesthesia. Because more oxygen may be used the possibility of anoxia is decreased. Both nitrous oxide and ethylene may be used over long periods of time without deleterious effects in the absence of anoxia.

*Vinyl Ether.* Vinyl ether (Vinethene) is an excellent inhalation anesthetic for brief surgical procedures. It possesses many of the pharmacologic attributes of the gases. Induction requires only 2 or 3 minutes and elimination requires about the same length of time. Like the gases, the vapor of vinyl ether is nonirritating and may be inhaled directly. The same cannot be said for the vapor of ethyl ether, the ordinary anesthetic ether which can be inhaled only by gradually conditioning the patient to it. As a consequence, "open drop" ether anesthetization, particularly in children, is preceded by vinyl ether anesthetization. The vapors of the volatile liquids are more potent than the gases. In most instances the alveolar concentrations necessary for surgical anesthesia range from 1 to 4 per cent. Most vinyl ether anesthetics are administered by the open drop method. To administer the drug (this also applies to other volatile liquids) only a cone and an airway are necessary. Uniformity of depth of anesthesia is maintained with difficulty if a rebreathing apparatus is employed. This may be due to the fact that the volatility of the drug makes it hard to regulate the concentration.

Although muscle relaxation is unsatisfactory under vinyl ether anesthesia, excellent analgesia is obtained. The drug causes no noteworthy systemic effects. Overdosage results in respiratory failure, which may be overcome by artificial respiration. Since the cardiovascular system is not affected by the drug, the chances of resuscitation, in the event of overdosage, are good. Nausea and vomiting are infrequent postanesthetic complications. The somnolence and drowsiness that follow administration of anesthetics like ether, chloroform or Pentothal do not occur with vinyl ether. Consequently, the drug is ideally suited for ambulatory patients. In patients who do not receive premedication with atropine, copious secretions which need to be removed by suction may develop. On occasions, particularly if anesthesia is deep, in patients who have had premedication, central nervous system excitatory phenomena such as twitchings and even convulsions may occur. These develop early during anesthetization and should cause no concern because they quickly disappear when administration is discontinued and another drug is substituted.

Vinyl ether is used most frequently for children but it is also suitable for adults. It is seldom used for operations lasting more than 10 or 15 minutes. Administration over long periods of time is not advised. When given to adults by the open drop technique large quantities are necessary. Comparatively speaking, it is more expensive than other volatile drugs. Extensive use in adults may be prohibited by the cost.

Vinyl ether may be combined with nitrous oxide in a semi-closed inhaler. The apparatus is set to deliver a mixture of 70 per cent nitrous oxide and 30 per cent oxygen. Adequate oxygenation is, therefore, assured. Vinyl ether is then added in sufficient quantity to fortify the mixture to produce a nonasphyxial anesthetic. This technique is used for dental extractions but is also suitable for minor surgical operations provided the apparatus is available. The drug, used alone or in combination with nitrous oxide, is suited for the ambulatory patient because it is rapidly eliminated.

*Ethyl Chloride.* Ethyl chloride, which has been widely employed as an inhalation anesthetic, is included in this discussion only to be condemned. It is used for identical purposes and is administered in a manner similar to vinyl ether. It is rapid in its action, easily inhaled and quickly eliminated. Induction and recovery are pleasant and rapid. Nausea and vomiting are uncommon postanesthetic sequelae. However, the drug has a pronounced effect upon the heart. In light anesthesia serious cardiac irregularities, believed to be due to strong vagal stimulation, frequently occur. In deep anesthesia depression of the myocardium, which may terminate in ventricular fibrillation or asystole, occurs. Unexpected deaths from the latter causes have occurred during its administration. Cardiac arrest may precede respiratory failure when overdosage occurs. Safer and equally useful anesthetics are available. *The drug is not recommended for inhalation anesthetization for any purpose.*

*Ethyl Ether.* Although in no sense ideal, ether is the safest of the inhalation anesthetics. It is recommended for minor surgical procedures only when an experienced anesthesiologist is not available or use of other drugs is contraindicated. It is common practice to resort to its use during operations on infants and children when the anesthesiologist begins with vinyl ether and later finds that the contemplated operating time has been underestimated. Anesthetization with ether requires a long, unpleasant induction period, which is often stormy, productive of much excitement and accompanied by excessive salivation. Recovery is slow and invariably accompanied by nausea, vomiting and excitement. These features make it an undesirable anesthetic for minor surgical procedures.

*Chloroform.* Chloroform is mentioned only to condemn it. It is both cardiotoxic and hepatotoxic. Irrespective of the skill of the anesthesiologist, death may result from asystole caused by myocardial depression. The dose that ordinarily causes respiratory failure in most instances also causes myocardial depression or cardiac failure. Thus, in the event of overdosage two emergencies arise: respiratory failure and impending circulatory failure. The drug possesses a narrow margin of safety (1.5 per cent alveolar concentration for surgical anesthesia, 2 per cent respiratory failure), and one easily passes from a surgical anesthetic concentration to the concentration producing medullary paralysis.

*Trichlorethylene.* Trichlorethylene (Trilene) resembles chloroform in its physical, chemical and pharmacologic properties. The drug has been used at times as an analgesic for afflictions of the fifth nerve. Recently, because of its noninflammable nature, it has been investigated for its general anesthetic properties. Its use as a general anesthetic has been abandoned because the results have been unsatisfactory. Besides, it is cardiotoxic. However, it is used as an analgesic for minor surgical procedures. Concentrations ranging from 0.25 to 1 per cent in air induce analgesia comparable to that obtained with nitrous oxide–oxygen mixture. Several inhalers have been devised for self-administration, the better

known of which are the Cyprane and Duke inhalers. These devices consist of a mask attached to a small cylindrical vaporizer through which air is drawn and mixed with the vapor on inhalation. The patient then exhales through a valve on the mask. A valve in the vaporizer prevents rebreathing. The proportions of air and vapor may be adjusted to suit the needs of the patient and the adjustment is locked with a key provided for the purpose.

Minor procedures, such as removal of dressings and suturing of small lacerations, may be attempted with analgesia in some patients. In these instances, trichlorethylene may be used. However, most surgical procedures require abolition of reflexes which can be obtained only with more profound anesthesia, in which case other substances must be used. Trichlorethylene should be used as an analgesic only and not as a surgical anesthetic. The drug is suitable for ambulatory patients if its use is strictly limited for analgesic purposes.

*Fluothane.* Fluothane also resembles chloroform in its physical, chemical and pharmacologic properties. It is of interest primarily because it is noninflammable and rapid acting. It is the most potent of the inhalational anesthetics. It is useful for fortifying nitrous oxide when general anesthesia is necessary for the ambulatory patient.

### Intravenous Route

Intravenous anesthetization appeals to most people because of its simplicity. For many years the search for a suitable drug for intravenous anesthetization has continued. Unfortunately, none has yet been found. Thus far, various barbiturates offer the best promise. The ultrashort-acting barbiturates produce a degree of basal narcosis which may be adequate for short surgical procedures. None of the barbiturates, including the ultrashort-acting ones, is analgesic and anesthetic. Therefore, attempts to abolish deep reflexes and painful stimuli with these drugs are often followed by overdepression, characterized by shallow respiration and hypotension.

The ultrashort-acting barbiturates widely used in surgery for basal narcosis or for anesthesia for short surgical procedures are hexobarbital (Evipal), thiopental (Pentothal), thiamylal (Surital) and methitural (Neraval). Hexobarbital is a nitrogen-substituted barbiturate. The others are sulfur-containing or thiobarbiturates.

Thiopental is by far the most popular of these and the most widely used. The usual concentration for intravenous administration is 2.5 per cent. One gram of the drug is dissolved in 40 cc. of distilled water or saline. Venipuncture is performed in the usual manner and the drug is injected at the rate of 1 cc. per 10 seconds initially and in fractional doses as needed during the course of the operation. Consciousness is lost within 40 or 50 seconds after injection of 0.1 to 0.2 gm. Depression of respiration invariably follows the initial injection. It is not uncommon for transient apnea lasting only 5 to 10 seconds to develop; then the patient resumes breathing, which is shallow at first, then progressively becomes normal. If the patient is not stimulated under these circumstances, he remains immobile, but if he stirs about when subjected to painful stimuli, additional thiopental must be given to abolish these responses to pain. In attempts to abolish these responses completely, the patient is often given an overdose, resulting in respiratory failure. Artificial respiration is then indicated. As a rule, circulatory depression does not occur.

In general, it is inadvisable to administer more than a total of 1 gm. of any of these ultrashort-acting barbiturates at any one time. The drug is withdrawn from the circulation after each fractional injection and stored in the lipid-containing tissues of the body. They appear to be detoxified at a constant rate, rather slowly. Barbiturates are detoxified by the liver. Use of excessive amounts over a period of time results in a cumulative action characterized by prolonged depression and hypnosis in the postoperative period. Only surgical procedures of brief duration, lasting 10 or 15 minutes, such as incision and drainage, manipula-

tion of fractures and suturing of minor wounds, should be attempted with thiopental as the sole anesthetic agent. The discreet anesthesiologist always combines these barbiturates with an analgesic substance. Nitrous oxide is an ideal analgesic. Its use reduces considerably the amount of barbiturates necessary, oftentimes to as little as 1/6 or 1/8 the amount needed if used alone. The concentration of nitrous oxide desirable is the maximum amount that can be given which will permit use of an adequate concentration of oxygen (70 per cent nitrous oxide, 30 per cent oxygen).

One of the objectionable features of thiobarbiturates, and to a lesser extent other short-acting barbiturates, is their spasmogenic activity—that is, they tend to cause laryngeal spasm. The cough reflex in the trachea or the bronchial tree is seldom abolished by these barbiturates and in many cases it is enhanced. Severe laryngeal and bronchial spasm is common, either during induction or maintenance of thiopental narcosis. It invariably follows attempts to insert airways, intratracheal tubes or bronchoscopes. If not properly managed, it may result in asphyxia. Secretions in the tracheobronchial tree, as in infections of the upper respiratory tract, or blood in oral and pharyngeal surgery, initiate severe spasm.

Aside from respiratory depression, spasmogenic activity, cumulative action and lack of analgesic effects, the ultrashort-acting barbiturates have no drawbacks. They do not affect the heart. Initial drops in blood pressure occasionally occur, but, in general, blood pressure is not adversely affected. If a patent airway is maintained and anoxia does not occur, the general metabolic processes are not disturbed. Hepatic function, renal function and various biochemical functions in the body are not seriously deranged. Nausea and vomiting in the postanesthetic period are uncommon. The ultrashort-acting barbiturates are, therefore, ideal as basal narcotics and highly satisfactory when combined with analgesic drugs (nitrous oxide, ethylene, cyclopropane).

Intravenous administration of barbiturates should not be used for ambulatory patients because ataxia, drowsiness and amnesia may persist for several hours after "awakening."

### General Remarks Concerning General Anesthesia

Certain generalizations are applicable to all forms of general anesthesia.

1. A general anesthetic, regardless of how brief the induction or how light the plane, should never be administered to a patient unless provisions are available for immediate institution of artificial respiration. The apparatus ordinarily employed for inhalation anesthesia may be used to administer artificial respiration by the intermittent insufflation technique. This method is wholly adequate for resuscitation under such circumstances as are encountered during surgical anesthesia. Unless an unimpeded airway is established, no method of artificial respiration will be successful. Airways of the pharyngeal type must always be on hand. Contrary to the teachings of certain anesthesiologists, endotracheal equipment and intubation are not absolute necessities for resuscitation. Valuable time is often wasted in attempts to introduce an endotracheal catheter before artificial ventilation is instituted. Intubation is indicated only after the usual measures for establishing an airway fail.

2. A suction apparatus for the exclusive use of the anesthesiologist must be in every operating room. A curved metal suction tip, which permits aspiration of secretions and vomitus from the hypopharynx, is essential. Catheters are unsatisfactory for this purpose because they are often used as the effects of the anesthetic are beginning to wear off and either they become kinked or the patient bites down on them. Besides, their flexibility makes them difficult to direct into the pharynx in order to accomplish thorough cleansing.

3. One of the poorest risks, from the standpoint of anesthetization, is the patient who has recently partaken of food or fluid. Operations on such patients should be deferred whenever possible.

Asphyxia accounts for the majority of deaths during or after general anesthesia, and aspiration of vomitus is one of the leading causes of asphyxia. Operation should be performed on a table which may be tilted to the head-down position in the event vomiting occurs, so that aspiration may be forestalled by allowing the gastric contents to gravitate into the nasopharynx.

4. Inflammable anesthetics should not be used in situations in which a fire hazard is present

5 Premedication should always be given, if possible. Attempts to anesthetize patients without adequate premedication lead to unsatisfactory results.

6 The anesthetic should be administered by an anesthesiologist. The tendency to consider anesthesia for minor surgical procedures less important than that for major operations is all too prevalent. A procedure of minor consequence from a surgical viewpoint may become a major one if performed under improperly administered general anesthesia. The practice of relegating administration of anesthetics for minor surgery to interns or other personnel not versed in the fundamentals of anesthesia should be condemned.

7. General anesthetics should not be administered in situations in which no provision is made for recovery from their effects. A recovery room with a bed, suction, emesis basins and all such paraphernalia is highly desirable.

8. Patients who have received narcotic drugs, intravenously administered barbiturates and other nonvolatile drugs may experience lingering effects of these substances for several hours after their administration. Therefore, it is unwise to use them for ambulatory patients.

### Preparation of Patients for General Anesthesia

The purpose of premedication is at least fourfold:

1. It is necessary for psychic sedation. One of the most difficult tasks of an anesthesiologist is to attempt to anesthetize an extremely apprehensive patient with an inhalation anesthetic. When nitrous oxide is used, this is well-nigh impossible.

2. It is necessary to obtain an additive effect to fortify a drug of low potency.

3. It is necessary to minimize or abolish secretions

4. It is necessary prophylactically to overcome undesirable side effects of anesthetic drugs, such as vagal stimulation (ethyl chloride) and hypotension.

For inhalation anesthesia the most suitable drugs for psychic sedation are the narcotics, which are superior to the barbiturates. Morphine is without question the most suitable drug. If morphine is contraindicated, related drugs, such as dihydromorphinone (Dilaudid), methadon, merperidine (Demerol) or anileridine (Lertine) may be substituted. Methadon and Demerol are good analgesics but possess poor hypnotic powers compared with morphine and are, therefore, not as suitable for psychic sedation as morphine or Dilaudid.

The time of administration of premedication is of extreme importance Clinical experience has shown that the optimum effects are achieved if morphine is administered 1 to 1½ hours prior to the anticipated time of induction, when the subcutaneous or intramuscular route is employed. In emergency operations the optimum effect may be secured within 5 minutes by intravenous administration of the medication. It cannot be emphasized too strongly that *narcotics must be injected intravenously at a slow rate (3 to 4 minutes).*

The belladonna alkaloids, atropine, hyoscyamine (Bellafoline) or scopolamine, are used as parasympathetic blocking agents to forestall secretion of mucus and saliva. Scopolamine and hyoscyamine are more effective than atropine. Scopolamine possesses a depressant action on the cerebral cortex. When scopolamine is administered with morphine, the two drugs act together to yield amnesia and excellent psychic sedation. The combination is preferred by the majority of anesthesiologists. The

belladonna alkaloids are usually administered simultaneously even when given intravenously. Most adults tolerate 1/4 grain (15 mg.) of morphine, combined with atropine or scopolamine, 1/100 grain. For patients older than 40 years 1/6 grain is advised. Patients in the sixth and seventh decades of life require 1/12 to 1/6 grain and those who are older 1/12 to 1/8. The belladonna alkaloid may be reduced to 1/150 grain in the older age group. The morphine may be omitted if the use of basal narcosis with the intravenous barbiturates is contemplated. In children and infants ultrashort-acting barbiturates may be administered rectally (1 gm. for each 50 lb. body weight) 1/2 hour before induction for basal narcosis and hypnosis.

### LOCAL AND REGIONAL ANESTHESIA

The regional or conduction anesthetics should be employed whenever possible for minor surgical procedures because their use obviates the risks and discomforts of general anesthesia and permits performance of such operations in the office or outpatient department. There is little question that regional anesthesia is the best form of anesthesia for the ambulatory patient. For minor surgery regional anesthesia is usually induced by (1) nerve block—a localized perineural injection of a suitable drug at an easily accessible site, proximal and away from the operative site; (2) infiltration—diffuse infiltration of the tissues at the surgical site, so that each individual nerve ending is blocked. This is the commonest technique used for minor surgery; (3) spinal block—subarachnoid injection of the drug, which blocks the anterior and posterior spinal roots. This may be desirable for surgical procedures on the lower extremity. Obviously, this type of block subjects the patient to the hazards peculiar to spinal anesthesia and converts the procedure from a minor to a major one; (4) caudal block—peridural injection of the drug. Caudal block, though less hazardous than spinal block, is not entirely without drawbacks. It is useful for operation on the perineal area.

#### Drugs

Numerous drugs are available for conduction anesthesia. In order to be of practical value for regional anesthesia a drug should possess the following qualities: (1) The anesthetic action should reach an adequate intensity within several minutes and its effect should last long enough to permit successful completion of the operation. (2) It should not cause local irritation immediately after injection and in the postoperative period. (3) It should not cause local tissue damage or retardation of healing. (4) Systemic toxicity should be low. (5) The drug should be stable and withstand heating for sterilization. (6) Its use should be compatible with vasoconstrictors, since the latter are often added to retard absorption and to decrease systemic toxicity.

Local anesthetics are basic substances capable of forming salts with mineral and organic acids. With few exceptions the majority are esters. The salts are water soluble. The bases are soluble in organic solvents, oils and vehicles used for ointments; most salts are not. Alkalies precipitate the bases from aqueous solutions of salts. Detoxification occurs in the liver, the rate varying with the drug. Certain drugs are completely hydrolyzed and the by-products excreted into the urine. Procaine, for example, is converted to para-aminobenzoic acid and diethylaminoethanol. Others are partly detoxified (cocaine) and partly recovered unchanged in the urine; still others are eliminated unchanged. Greater toxicity is usually associated with slowly eliminated or slowly detoxified drugs.

The effective concentration of a local anesthetic varies with the size of the nerve fiber. Autonomic and sensory fibers of a mixed nerve are smaller than the fibers of a motor nerve. A nerve composed of all three components exposed to a dilute solution of a local anesthetic drug first develops a blockade to sensory stimuli and autonomic impulses, but retains conduction in its motor components for a variable period. Later the

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be used for smaller nerve trunks and for infiltration. The limit should be 1 gm. at any one sitting.

*Lidocaine* (Xylocaine). Numerous local anesthetics have recently been offered for clinical trial, but few have proved to be as valuable an addition to the long list of local anesthetics as lidocaine. Although it is not an ester, it does possess the general chemical configuration common to other local anesthetics. It produces immediate anesthesia. When infiltrated it produces an effect lasting between 1 and 1½ hours without epinephrine, and from 2 to 3 hours with epinephrine. The volumes and strengths of solutions are approximately one-half to two-thirds those of procaine in similar situations. The conventional concentrations and volumes at any one sitting are: 0.5 per cent, not more than 100 cc.; 1 per cent, not more than 50 cc.; 2 per cent, not more than 25 cc. A 4 per cent solution is used for topical application.

Lidocaine possesses striking ability to diffuse through tissues. Thus, if perchance the needle is introduced some distance from the nerve, an effective block is still obtained because the drug diffuses widely and reaches the nerve. The incidence of failures is reduced noticeably in many of the more difficult blocks. Blocks in which motor effects are partial or absent when procaine is used yield complete flaccidity with lidocaine.

*Dibucaine* (Nupercaine) is approximately fifteen times more potent and toxic than procaine. Its effect is longer lasting than that of any of the currently used drugs. Nerve blocks may be performed with 0.075 per cent solutions, and infiltration with 0.05 per cent. Sloughing and severe systemic manifestations of toxicity have been reported from time to time. The drug is not recommended for infiltration and nerve blocking. It is suitable for spinal anesthesia, however.

*Chlorprocaine* (Nesacaine). This local anesthetic is somewhat less toxic but more potent than procaine. Its uses, strengths and volumes of solutions are similar to those of procaine.

*Hexylcaine* (Cyclaine). This local anesthetic is somewhat less toxic but more potent than procaine. The strengths and volumes of solutions used are similar to those of procaine. A 5 per cent solution is used for topical application.

### Solutions

Commercially prepared, ready mixed and sterilized solutions are available in sealed glass ampules or multiple dose vials. Such preparations are preferred for safety, stability, asepsis and ease of handling to those made up from tablets and powders. Accidents due to improper dilution or use of concentrated solutions and the possibility of contamination are averted. When these preparations are not available, the powder may be dissolved in the appropriate solvent and sterilized by autoclaving or boiling. Vasoconstrictor substances are not stable and are best added at the time the solution is used. A solution that is as nearly isotonic as possible is desired in order to avoid swelling and edema of tissues during the operation and local irritation afterwards. The potent drugs, such as tetracaine or dibucaine, may be dissolved directly in physiologic saline, since the amount necessary for effectiveness is comparatively minute and the tonicity is not altered. Solutions of procaine in distilled water, less concentrated than 4 per cent, are not isotonic. A 2 per cent solution of procaine must be prepared with 0.45 per cent saline to be isotonic.

### Materials

Elaborate needles, syringes, stopcocks and other devices available for induction of regional anesthesia are not necessary. Regional anesthesia can be successfully induced with simple equipment. Elaborate equipment does not supplant technical knowledge and skill. Sharp needles and leakproof syringes which are not awkward to hold will suffice. The length of the needle varies with the type of block to be performed and the size and weight of the subject. Usually 5, 8 or 10 cm. stainless steel needles of 22 or 24 gauge bore, with long bevels, are adequate for most blocks. A 1.5 or 2 cm. 25 gauge needle for intradermal injec-

motor components are affected. This variation depends upon the degree of penetration. Nonmyelinated fibers are penetrated more easily than myelinated. Penetration into the large nerve trunks, since they have a denser perineural sheath than the smaller trunks, occurs more slowly and is more difficult than in the case of smaller nerves. More concentrated solutions are required for successful blockade of the larger, centrally located nerve trunks than of the smaller, peripherally located branches. Less concentrated solutions are effective in blocking the nerve endings themselves because they are unsheathed and penetration occurs with greater ease. For brachial plexus block with procaine, for example, rarely does satisfactory anesthesia result unless a 2 per cent solution is used The median nerve at the wrist, on the other hand, can be successfully blocked with a 1 per cent solution. The nerve endings in the skin and subcutaneous areas are easily anesthetized with 0.5 per cent solution of procaine.

For large nerve trunks, such as the components of the brachial or lumbosacral plexus, sometimes as much as 15 or 20 minutes may elapse before a satisfactory block is accomplished. This lapse of time from the moment of injection until a blockade results is the sum of time required for the drug to diffuse through the soft tissues to the neural sheaths and the perineural nerve membrane into the nerve fiber. The ease of penetration of a drug through the membrane is a physical factor dependent upon the configuration of the molecule. This latent period is greater for the longer lasting drugs. Presumably, a longer lasting drug, when applied to a nerve, diffuses in slowly and diffuses out slowly when the concentration of drug in the medium surrounding the nerve fiber is reduced below the equilibrium level. This is the reason why the onset of anesthesia is more rapid and duration briefer with procaine than with pontocaine.

***Procaine*** (Novocain) is one of the safest local anesthetics and is almost the universal agent of choice for local and regional anesthesia. It is rapidly detoxified and eliminated, reactions are mild when they occur, and local damage to tissues is uncommon. The conventional concentrations and volumes for average adults are as follows: 2 per cent, not more than 50 cc. in 1 hour; 1 per cent, not more than 100 cc., and 0.5 per cent, not more than 200 cc.; or roughly speaking not more than 1 gm. at any one sitting. Since procaine possesses no topical action, it cannot be used to anesthetize mucous membranes. The duration of action is approximately ¾ hour but varies with the site of injection, blood supply, concentration and ability to detoxify the drug.

***Tetracaine*** (Pontocaine) is more potent and more toxic than procaine. It is second only to procaine as a suitable regional anesthetic. One milligram of tetracaine roughly provides the same amount of anesthesia as 10 mg. of procaine. The duration of action of tetracaine is almost twice that of procaine. When epinephrine is added to a solution of tetracaine, regional blocks lasting from 2 to 4 hours are possible. Tetracaine has enjoyed greatest popularity as a spinal anesthetic drug. Large nerve trunks may be blocked with a 0.15 per cent solution; smaller, with a 0.10 per cent solution. A 0.05 to 0.075 per cent solution has been used for infiltration. Symptoms of toxicity are more frequent than with procaine. Fatalities from overdosage are reported from time to time. These appear to be characterized by syncope and circulatory collapse. In many instances, few, if any, prodromal symptoms forewarn impending catastrophe. Use of tetracaine for regional anesthesia should be reserved for those experienced in the technique of regional anesthesia.

***Piperocaine*** (Metycaine) is closely allied to cocaine chemically, being an ester of benzoic acid. Although similar to procaine in most respects, it is somewhat more potent and longer lasting. One and one-half per cent solutions are suitable for blocking large and medium sized nerve trunks; 1 per cent solution should

dismissed as "hysteria." The severity and duration of the convulsions depend upon the pharmacologic nature and rapidity of absorption of the drug. If large amounts are absorbed, the convulsive manifestation may be fleeting and is followed by a paralytic phase. The subject is then comatose, completely depressed and in a state of circulatory collapse. The convulsions are easily controlled by the intravenous administration of an ultrashort-acting barbiturate, such as thiopental or Evipal. If neither of these is available, one of the short-acting barbiturates, such as secobarbital (Seconal) or pentobarbital (Nembutal), may be used.

The barbiturate must be given intravenously in sufficient quantity to control the convulsions. The ultrashort-acting barbiturates are more suited for controlling convulsions because they act within 1 minute and are more potent. A 3 or 4 minute period precedes the peak of action of the short-acting barbiturates, during which time the convulsions persist. Overdosage may occur if administration of these longer acting barbiturates is continued during the prepeak phase. One hundred to 150 milligrams (1.5 to 2 grains) is first given and sufficient time is allowed for its action to become manifest before a second fraction is administered. Barbiturates merely antagonize the stimulating action. They neither hasten detoxification or elimination of the local anesthetic nor overcome the depressant effect on the circulation. They are, therefore, not suitable for the depressant type of reaction.

It is unwise to attempt to obtain any type of regional anesthesia without having on hand an ultrashort-acting barbiturate, a vasopressor, syringe and needle, and some effective method of administering artificial respiration. Incidentally, the pallor, tachycardia, tremor and excitement caused by the addition of epinephrine to the drug may easily be confused with the early phase of a reaction.

***Testing for Sensitivity.*** Use of the intradermal wheal to determine sensitivity to local anesthetic drugs is a traditional procedure of doubtful value. The test is often difficult to interpret because areas of erythema, which frequently develop at the site of needle puncture, are often confused with pseudopod formations. Signs of intolerance have been alleged to appear when the test yielded a negative result. On other occasions nothing has happened when the drug was administered regardless of a "positive reaction." Patients giving a history of "passing out" after injection of small quantities of local anesthetic drugs should be regarded with suspicion and studied further before a block is attempted. Certain clinicians employ the intranasal test, the value of which remains to be established; however, it appears to have a sounder scientific basis than the skin test. The test is performed in the following manner. A base line of pulse and blood pressure readings is taken at 2 or 3 minute intervals for 5 minutes with the patient in the recumbent position. One drop of the solution to be used is then instilled into one nostril and pulse rate and blood pressure readings are recorded every minute for 3 minutes. If no change occurs, 2 drops are placed in the nostril, and blood pressure and pulse rate are again recorded at intervals of 1 minute for 3 minutes. Four drops, then 8, then 16 are instilled and the blood pressure is recorded in the same manner after each instillation. Any remarkable change of the pulse or fall in blood pressure should be regarded as a manifestation of intolerance.

Most reactions to local anesthetic drugs are due to misuse of the drug. Failure to attempt aspiration, use of unnecessarily concentrated solutions and omission of epinephrine when the drug is injected in highly vascular areas are some of the errors which lead to disaster. In the management of reactions to local anesthetics prevention is better than cure.

### Preparation of the Patient

Most of the remarks concerning preparation of the patient for general anesthesia are applicable to local and regional anesthesia. In patients undergoing

tions is also necessary. It is not only poor technique but dangerous to introduce a needle to the hub. It is desirable, although not mandatory, to have one needle for each injection site. The possibility of infection in the event of contamination of one needle is thereby averted. Each needle should be furnished with a marker for gauging depths below skin surface. Markers may be made by cutting ¼-inch squares from a section of latex rubber infusion tubing. Syringes of the lock type with glass plungers of 5 or 10 cc. capacity are satisfactory for most blocks. Ordinarily, needles are introduced without the syringe attached and with stylets in place, particularly when they traverse fibrous tissue. Nonirritating skin sterilizers, gloves, towels for draping and skin marking pencils are other necessary items.

### Vasoconstrictors

The most efficient vasoconstrictor drug for local anesthesia is epinephrine. (Ephedrine, Neo-Synephrine, synephrine and numerous other amines are in no way as efficient or effective.) Epinephrine is not chemically stable and does not withstand exposure to air or sterilization by heat. Satisfactory results are obtained only when the epinephrine is added at the time the block is performed. Commercial solutions of local anesthetic drugs with added epinephrine in sealed ampules contain stabilizers that retard oxidation. The usual effective dilution of epinephrine is between 1:50,000 and 1:100,000. One milligram (1 cc., 1:1000) is added to 50 to 100 cc. of solution. Pallor, tachycardia, anxiety, tremors and nausea may follow the use of epinephrine. Epinephrine should never be given to patients with cardiovascular disease, peripheral vascular disease, hyperthyroidism, or those who have had sympathectomy or are emotionally disturbed. *Solutions containing epinephrine should not be injected into the appendages such as the fingers, toes, ears or the penis of certain patients, notably those with peripheral vascular disease.* Gangrene and slough have occurred.

### Precautions and Management of Reactions

Local and regional anesthetics are not entirely without hazards. When a sizeable quantity of local anesthetic drug inadvertently gains access into the blood stream, or a small amount is quickly injected or absorbed, the patient responds with a train of symptoms commonly referred to as a "reaction." Two types of toxic reactions are recognized: (1) the *vascular or depressant* type, and (2) the *stimulating* or *convulsive* type. The depressant type of reaction is due most often to circulatory collapse. Local anesthetics cause circulatory collapse by depression of the myocardium, dilatation of the vascular bed, or a combination of both. The onset is usually abrupt, sometimes after injection of a minute amount of drug. Under these circumstances the first sign is sudden appearance of pallor, syncope, complete collapse and respiratory failure. Death follows quickly. In less severe cases circulatory failure supervenes gradually, the patient becomes drowsy and eventually passes into a coma-like state. These manifestations of toxicity have often been ascribed to "idiosyncrasy" or "sensitivity." Although intolerance to a drug may be responsible for some cases, such responses are more commonly the result of overdosage and failure to observe the precautions outlined for using local anesthetics.

In severe cases of circulatory depression, vasopressors, such as ephedrine, 25 to 50 mg., or phenylephrine (Neo-Synephrine), 0.5 to 1 mg., are administered intravenously. If respiration ceases and asystole is suspected, cardiac massage and artificial respiration must be instituted simultaneously without delay.

Fortunately, reactions characterized by sudden syncope are less common than those ushered in by convulsions, excitement or other manifestations of central nervous system stimulation. When the stimulating type of reaction occurs, excitement, pallor, yawning, nausea and vomiting frequently precede the convulsions. Often these prodromal signs are

direct interruption of nerve impulses is selected when the operative site is in an area supplied by one or two nerves which are easily accessible. In certain areas of the body, as for example the upper thorax, there is overlapping of many nerves so that interruption of their impulses is unsatisfactory unless it is extensive, in which case the anesthetic procedure often assumes a greater magnitude than the operation itself. Nerve blocks are thus more suitable for operations on the extremities than for those on the head and trunk.

A field block produces anesthesia which is intermediate between that produced by nerve block and that produced by infiltration. In field blocks the anesthetic is deposited locally at a site through which branches of the single or several nerves pass so that the area distal to these branches is anesthetized. Infiltration along the costal margin from the xyphoid process to the tenth rib will cause loss of sensation of the upper abdominal area on the side injected by anesthetizing the branches of the lower intercostal nerves.

*Brachial Plexus Block.* There are a number of simple blocks which can be used for minor surgery. One of the most widely used is the brachial plexus block, which produces anesthesia of the arm and forearm. It is accomplished by infiltration of the trunks, divisions or cords of the plexus with a local anesthetic solution. Several techniques have been described. In general, two types of brachial block are recognized: the supraclavicular and the axillary types. Supraclavicular blocks are fraught with certain hazards, notably development of pneumothorax and trauma to great vessels, which remove them from the realm of simple procedures.

"ONE POINT" SUPRACLAVICULAR BLOCK. The most popular supraclavicular block is the "one point" block. It is performed by placing the patient in the supine position with the arm on the side to be injected in slight abduction and the head rotated in the opposite direction. With the operator standing on the side of the patient to be injected, a point midway along, and 1 cm. above, the superior border of the clavicle (Fig. 32) is determined by bisecting the distance between the acromioclavicular and the sternoclavicular joints. The lateral border of the subclavian artery above the clavicle,

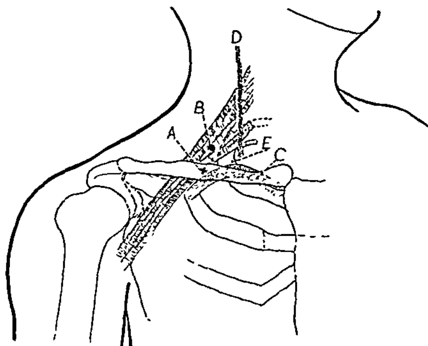



*Figure 32.* Landmarks for brachial plexus block by the supraclavicular route. *A*, Midpoint of the clavicle. *B*, Site of injection. *C*, Subclavian artery. *D*, External jugular vein. *E*, First rib. (From "Techniques and Procedures of Anesthesia," by John Adriani, M. D., Charles C Thomas, Publisher, Springfield, Illinois)

elective surgical procedures it is advisable to withhold food. Regardless of the extent of the operation or the type of anesthetic, nausea and vomiting are common if the stomach is full. Surgical manipulations, apprehension and the effects of epinephrine and the local anesthetic drug, *all may initiate vomiting.* Pre-anesthetic sedation is desirable but should be omitted if the patient is to be ambulatory immediately after the operation. As mentioned heretofore, ambulation after administration of opiates is undesirable. Ataxia and drowsiness are not uncommon and may induce nausea and vomiting. Morphine and scopolamine in dosages employed for general anesthesia may be used when the patient is to be hospitalized. Barbiturates are usually recommended prior to regional anesthesia, not only to allay apprehension but also to minimize the possibility of convulsions due to the local anesthetic drug. Even though barbiturates antagonize the stimulation caused by local anesthetic overdosage, it must be emphasized that the quantity necessary to inhibit convulsions is a basal narcotic dose. One and one-half grains (100 mg.) of secobarbital or pentobarbital orally or intramuscularly 1½ hours prior to operation usually allays excitement and minimizes convulsions but does not prevent them. All efforts should be made to perform operations under circumstances which allow use of premedication. Many a successful block is not satisfactory because the patient is apprehensive.

### Techniques

***Infiltration Anesthesia.*** As a rule, most minor surgical procedures may be performed after infiltration of the operative site with the chosen local anesthetic. Needle puncture of the skin should always be preceded by a skin wheal. To raise a skin wheal properly a drop of the solution is first placed at the point of entry of the needle. The wheal needle, bevel downward, is then slowly advanced with a wiggling motion through the epidermis. Initial entry of the needle through the skin is painless when the wheal is raised in this manner. As soon as the needle has passed through the epidermis, a quantity of solution sufficient to cause a blanched area with an "orange skin" appearance is introduced. All subsequent injections and insertions of the needle may be made through this wheal in patients whose operative site is *limited. A more extensive site may require raising a wheal at another point.* If, for example, a circular lesion, such as a mole or lipoma, is to be excised, a skin wheal is raised at each pole and the wheals are extended in a circular manner to circumscribe the lesion along what is to be the proposed line of incision. A longer needle is then introduced, and the drug is injected subcutaneously and in the deeper tissues under the lesion. Infiltration anesthetization is the technique of choice for minor operations, such as excision of moles, scars, fibromas and lipomas.

***Topical Anesthesia.*** Local anesthetic drugs in aqueous solutions do not penetrate the unbroken skin to any appreciable extent. If they are mixed with oily or cream bases, the degree of penetration is increased to the extent that analgesia is obtained for burns and excoriated or denuded areas. They easily penetrate into and are absorbed by mucous membranes. In many instances, if care is not exercised, absorption will be rapid enough to produce manifestations of systemic toxicity. Certain drugs possess little or no topical action. Cocaine in 4 per cent solution appears to be the most widely used drug. Tetracaine (Pontocaine), which is more potent and toxic, has been the cause of numerous fatalities and is therefore not recommended for general topical use. Lidocaine in a 4 per cent solution, or hexylcaine in a 5 per cent solution, is effective topically. Reactions are more frequent after topical application than after injection. Blood levels after pharyngeal or tracheal instillation are comparable to those resulting from intravenous administration. A safe short-acting topical anesthetic is a 20 per cent solution of benzocaine in an oxyquinoline base (Americaine). Benzocaine is poorly soluble in water.

***Nerve Blocks.*** Regional anesthesia by

A ¾-inch 25 gauge needle attached to a 10 cc. syringe is suitable for thin subjects. For muscular and obese individuals a 1- or 1¼-inch 25 gauge needle is desirable. With the thumb and index finger the artery is palpated and retracted posteriorly in order to remove it from the path of the needle. The median nerve is then easily palpable around the artery. The needle is introduced directly perpendicular to the skin and to the humerus towards the median nerve (Fig. 33). Paresthesias are felt in the finger tips. Five cubic centimeters of a 2 per cent solution of procaine is then injected at this point. The needle is withdrawn almost to the skin and reintroduced at an angle 45 degrees anterior to the direction of the first injection. The point will thus be directly toward the insertion of the pectoralis major muscle. This maneuver is designed to inject the musculocutaneous nerve, which at this point is invariably close to the artery. Paresthesias are felt at the elbow joint. Five cubic centimeters of a 2 per cent solution of procaine is introduced at this point.

The needle is again withdrawn almost to the skin. The artery is then retracted anteriorly toward the upper surface of the arm and the ulnar nerve is palpated on the under surface. The needle is then directed posteriorly downward at an angle of 45 degrees to the plane of the original injection for the median nerve. Paresthesias corresponding to the distribution of the ulnar nerve to the fourth and fifth digits are felt. Five cubic centimeters of a 2 per cent solution of procaine is injected at this site. The radial nerve is then blocked. The radial nerve is the least accessible element of the plexus at this site because it is deepest and is posterior to the artery and, therefore, not palpable. The median and ulnar nerves are easily palpable.

The needle is once again withdrawn almost to the skin and with the artery still retracted upward, the needle is reintroduced at an angle of almost 90 degrees to the plane of the injection for the median nerve. Paresthesias corresponding to the distribution of the radial nerve along the back of the hand must be felt. Failure to produce paresthesia is usually followed by failure to obtain anesthesia in the dorsum of the hand; 5 cc. of a 2 per cent solution of procaine is injected at this site. The syringe should remain attached to the needle throughout all maneuvers. It is absolutely imperative that the needle be at a right angle to the shaft of the humerus at all times; it should not be angulated in any way toward the axilla or down the arm so that it tends to parallel the humerus, muscles and nerves. Aspiration before each injection must be attempted. The injection site is massaged gently for 5 minutes.

*Median Nerve Block at the Elbow.* The median nerve may be blocked at either the elbow or the wrist. When block at the elbow is attempted, the landmarks are the brachial artery, the tendon of the biceps and the internal condyle of the humerus. The patient is placed in the supine position with the arm abducted and forearm extended. An

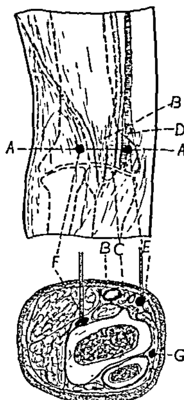



*Figure 34.* Landmarks for median and radial nerve block at the elbow: *A–A*, Line above crease of elbow. *B*, Tendon of biceps. *C*, Brachial artery *D*, Vein. *E*, Median nerve. *F*, Radial nerve beneath brachioradialis muscle. *G*, Ulnar nerve (From "Techniques and Procedures of Anesthesia" by John Adriani, M.D., Charles C Thomas, Publisher, Springfield, Illinois.)

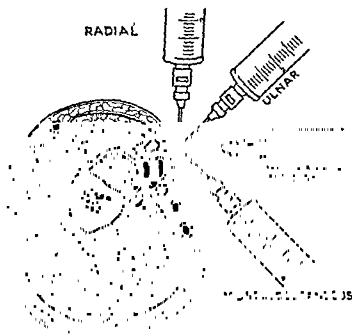



*Figure 33.* Cross section through axilla at the level of the insertion of pectoralis major and teres major The needle is introduced perpendicularly to the humerus and inclined at the various angles to inject the corresponding elements of the plexus. (From "Brachial Plexus Block: A Simplified Technic Using the Axillary Route" by Nick J. Accardo, M.D., and John Adriani, M.D, South. M. J., 42:920–923, 1949)

and the external jugular vein, are then identified The latter passes downward and medial to the midpoint of the clavicle. An intradermal wheal is raised 1 cm. above the midpoint of the clavicle and a 5 cm needle unattached to a syringe is introduced through the wheal, care being exercised to avoid the artery and the vein. The marker is set for 1.5 cm and the needle is advanced posteriorly, caudad and medially at an angle of approximately 60 degrees until the first rib is encountered. Care must be taken not to advance the needle any farther than the marker if the rib is not encountered. The needle should be withdrawn 2 or 3 mm. after the rib is encountered so that it lies in the same fascial compartment as the brachial plexus, which lies superficial to the deep fascia of the neck. A drop of anesthetic solution is placed on the open end of the hub of the needle and the patient is instructed to take a deep breath in order to determine whether or not the pleura has been pierced. There should be no movement of the drop. Then 25 cc. of a 2 per cent solution of procaine or an equivalent volume of solution of another drug is injected. Frequent aspirations should be done during the injection. The hand, fingers and forearm will be completely anesthetized within 10 to 15 minutes. The skin in the axilla and over the upper arm does not become anesthetized. The patient is usually able to use the fingers and thumb. When lidocaine or tetracaine is used, motor paralysis is obtained. This block is suitable when procaine is used in the repair of tendons or similar operations, in which it is desirable not to abolish motor effects completely.

AXILLARY ROUTE. When the axillary route is used, the patient is placed in the supine position with the arm abducted at 90 degrees and allowed to rest on a support in external rotation. The axillary hair is shaved and the patient is surgically prepared and draped. The humeral insertions of the latissimus dorsi posteriorly and the pectoralis major anteriorly are palpated. A vertical line, drawn between these two points, is bisected and the point marked. This point lies directly over the brachial artery, which can be palpated in all except extremely obese subjects. A wheal is raised at this point with a 2 per cent solution of procaine or other desired solution.

longus, flexor carpi ulnaris and flexor carpi radialis tendons are marked. An intradermal wheal is raised between the first two of the above tendons on a transverse line through the styloid of the ulna, and a 5 cm. needle is introduced perpendicular to the skin through the superficial and deep fascia and advanced 0.5 cm. beyond the deep fascia. Two cubic centimeters of a 2 per cent solution of procaine is then injected at this site and followed by gentle massage.

*Ulnar Nerve Block at the Wrist.* The landmarks are the same as for median nerve block at the wrist, except that the tendon of the flexor carpi ulnaris muscle is used (Fig. 36). The patient is in the same position with the hand in supination. The tendon of the flexor carpi ulnaris is palpated at the level of the styloid and an intradermal wheal is raised on the radial side of the tendon of the flexor carpi ulnaris on the line through the ulnar styloid. A 5 cm. needle is introduced perpendicular to the skin and the deep fascia is pierced. When paresthesias are felt, 3 cc. of a 2 per cent solution of procaine is injected.

*Radial Nerve Block at the Wrist.* The lateral branch of the radial nerve is anesthetized by locating the anatomic snuffbox, making the tendons prominent, and injecting 3 cc. of a 2 per cent solution of procaine through a wheal raised at this site. The medial branch is blocked by infiltration of the subcutaneous tissues around the wrist.

*Block of the Thumb and Fingers.* For minor surgical procedures the nerves in the fingers may be blocked, although in most instances it may be desirable to block the nerves at the wrist, elbow, or brachial plexus for operations on the hand. The patient is placed in the supine position with the dorsum of the hand upward. The metacarpal bones are palpated. An intradermal wheal is raised on each side of the midpoint of the metacarpal bone of the digit to be anesthetized, or of all the digits if desired. A 5 cm. needle is advanced towards the

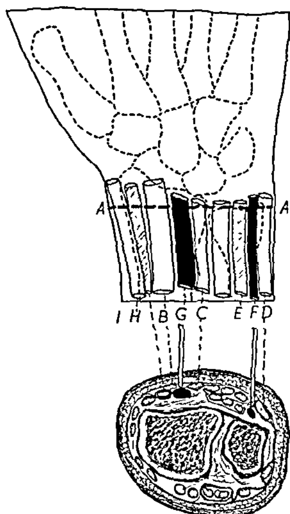



*Figure 36* Landmarks for median and radial nerve block at the wrist. *A–A*, Transverse line through ulnar styloid for determining point of injection *B*, Flexor carpi radialis longus tendon. *C*, Palmaris longus tendon *D*, Flexor carpi ulnaris tendon. *E*, Ulnar artery. *F*, Ulnar nerve. [illegible] "Tech- [illegible] by John [illegible] ublisher, Springfield, Illinois)

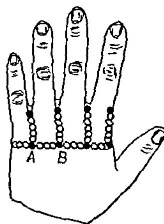



*Figure 37.* Block of thumb and fingers. Intradermal wheals are raised at points *A* and *B* which are located at midpoint on each side of the metacarpal bone of the digit to be anesthetized. (From "Techniques and Procedures of Anesthesia" by John Adriani, M.D., Charles C Thomas, Publisher, Springfield, Illinois)

applicator moistened with iodine or ink is placed in the cubital fossa. The forearm is then flexed on the arm to make an angle of 90 degrees. A transverse line results (Fig. 34). The tendon of the biceps may be felt by flexing and extending the forearm with the hand in supination. The brachial artery may be palpated medial to the tendon. An intradermal wheal is raised medial to the artery and a 5 cm. needle is introduced through the wheal perpendicular to the skin through the superficial and deep fascia. Paresthesias are sought. Three cubic centimeters of a 2 per cent solution of procaine is injected at this site. Two or three cubic centimeters more is injected in fanwise manner over the path of the nerve. With procaine a garter may be circumscribed intracutaneously and subcutaneously above the site of injection in order to block nerves which anastomose with the median nerve from the upper arm.

*Radial Nerve Block at the Elbow.* The radial nerve may also be blocked at the elbow and wrist. When block at the elbow is attempted, the same transverse line is used as for block of the median nerve (Fig. 34) and the position of the patient is the same. An intradermal wheal is raised 1 cm. lateral to the tendon of the biceps on this line. A 5 cm. needle is introduced through the wheal perpendicular to the skin. The index finger of the left hand is then placed at the posterior aspect of the lateral condyle of the humerus and the needle is then advanced in the direction of the finger until bone is encountered. Paresthesias are felt at this site and 2 to 5 cc. of procaine is injected.

*Ulnar Nerve Block at the Elbow.* The ulnar nerve may be blocked at the elbow or wrist. The landmarks are the groove between the internal condyle of the humerus and the olecranon process. The patient is placed in the lateral prone position on the side opposite the one to be injected. The arm is allowed to rest alongside the body. With the thumb and index finger of the left hand the nerve is palpated and grasped above the groove. An intradermal wheal is raised

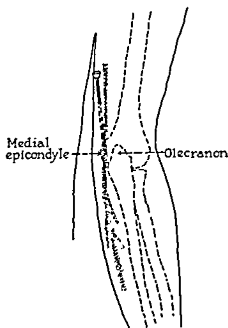



*Figure 35.* Landmarks for ulnar block at the elbow. (From "Techniques and Procedures of Anesthesia" by John Adriani, M.D., Charles C Thomas, Publisher, Springfield, Illinois)

on the tip of the fold of the skin thus grasped. The wheal should be 3 cm. above the bony prominence (Fig. 35). A 5 cm. needle is inserted in the direction of the nerve, nearly parallel to it for a distance of several centimeters. The needle will be parallel to the shaft of the humerus. As soon as paresthesias are felt, 5 cc. of a 2 per cent solution of procaine is injected. Anesthesia is not obtained when the needle is introduced perpendicular to the skin and comes down directly upon the ulnar nerve.

By block of the median, ulnar and radial nerves at the elbow anesthesia of the forearm may be obtained. In order to produce complete anesthesia of both the forearm and hand it is necessary to raise a circumscribed garter intradermally and subcutaneously about 1 or 2 inches above the fold of the elbow.

*Median Nerve Block at the Wrist.* The landmarks are the tendons of the palmaris longus and flexor carpi radialis muscles, and the styloid process of the ulna. The patient is placed in a supine position with the arm on a board and the palm facing upward. A cross is marked on the anterior aspect of the wrist through the styloid of the ulna (Fig. 36). The outlines of the palmaris

ting position with his arms at his sides and the operator facing him. An intradermal wheal is raised 1 cm. medial to the midpoint and just above the upper border of the clavicle. A 10 cm. 22 gauge needle is introduced horizontally through the wheal in a posterior medial direction at an angle of 45 degrees to the skin towards the body of the first thoracic vertebra for a distance of 6 or 7 cm. When the body of the seventh thoracic junction of the body of the first thoracic and the seventh cervical is encountered, 5 cc. of a 2 per cent solution of procaine or 10 cc. of a 1 per cent solution of procaine is injected (Fig. 39 *A* and *B*).

PARATRACHEAL ROUTE. The index and middle fingers of the left hand are held several centimeters apart. The index finger is placed at the sternoclavicular joint and both fingers, still held apart, are pushed between the carotid bundle and the trachea, and the carotid bundle is retracted laterally. The tips of the fingers rest upon the lateral aspect of the body of the cervical vertebra. A hypodermic needle attached to a syringe containing

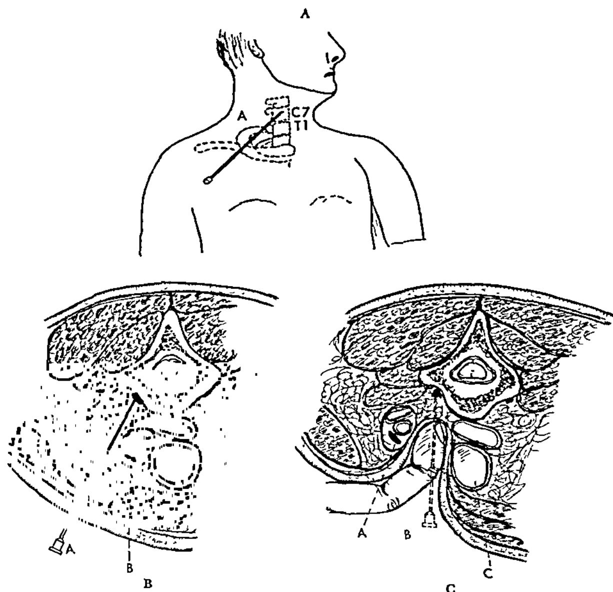



*Figure 39.* Stellate ganglion block.

*A.* Anterior approach. The needle is directed towards the body of the 7th cervical vertebra at a point 1 cm above the midpoint of the clavicle.

*B.* Anterior approach Placement of the needle. (From "Nerve Blocks" by John Adriani, M.D., Charles C Thomas, Publisher, Springfield, Illinois.)

*C.* Paratracheal approach. The finger retracts the carotid bundle laterally. The needle is introduced at a level one fingerbreadth above the sternoclavicular joint in an anterior-posterior direction.

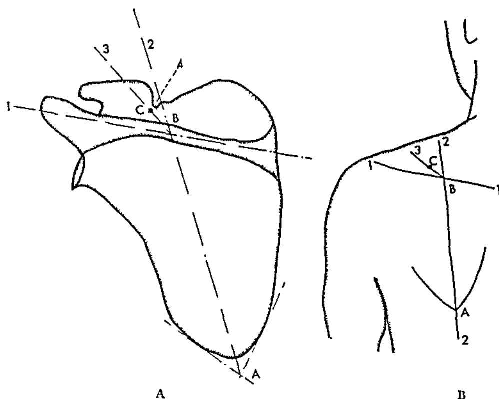



*Figure 38.* Suprascapular block.

*A* Line 2 is drawn by bisecting the lower angle of the scapula at *A*. Line 1 is drawn along the spine of the scapula. Line 3 is obtained by bisecting the upper, outer quadrant formed in the intersection of lines 1 and 2.

*B*. The skin wheal is raised at point *C*, which is 1½ cm. along line 3 from point of intersection of lines 1 and 2 The wheal is raised in the outer, upper quadrant of the intersecting lines (From "Nerve Blocks," by John Adriani, M.D., Charles C Thomas, Publisher, Springfield, Illinois)

palm perpendicular to the skin and a 1 per cent solution of procaine is injected as the needle is advanced (Fig. 37). The area from the wheal to the web of the finger on either side is then infiltrated.

*Block of the Digits.* The landmarks for blocking the digits are the phalanges proximal to the site of operation. The dorsum of the finger to be anesthetized should face upward. An intradermal wheal is raised on the dorsum of the digit over the phalanx and a 1 per cent solution of procaine is injected through the skin to the bone on one side. The needle is then almost completely withdrawn and inserted on the other side, and injection is accomplished in the same manner.

*Suprascapular Block.* Suprascapular block is useful for relief of pain in the shoulder due to arthritis, bursitis and various periarticular afflictions. It provides no cutaneous anesthesia, however, since the nerve is primarily sensory to the joint. The block is performed with the patient in the upright sitting position. A line is drawn with a skin-marking pencil over the spine of the scapula. The lower angle of the scapula is outlined and bisected and the bisecting line is drawn cephalad so that it intersects the line along the spine. The upper outer quadrant is then bisected and a wheal is raised 1.5 cm. from the point of intersection along the resulting line (Fig. 38). A 10 cm. 22 or 24 gauge needle is introduced perpendicularly until the surface of the scapula is encountered. The needle is withdrawn almost all the way to the skin and is reintroduced towards the midline and cephalad at an angle of approximately 60 degrees to the skin, being directed towards the scapular notch. If the scapula is again encountered, the needle is withdrawn and reintroduced until it is felt to slip off the edge of the notch.

*Stellate Ganglion Block.* ANTERIOR ROUTE. The patient is placed in the sit-

opposite the spine at a point 4 cm. from the midline at the level of the process. An 8 cm. needle is introduced perpendicularly to the skin until the rib or the outer edge of the transverse process is encountered (Fig. 42). A distance of 2.5 cm. is marked off on the shaft and the needle is advanced at an angle of 45 degrees caudad so that it glances off the edge of the rib. The needle is withdrawn almost to the skin and is reintroduced towards the lower edge of the rib into the space between the transverse processes. Five cubic centimeters of a 10 per cent solution of procaine is injected. The procedure is repeated for the ribs above and below or for as many ribs as de-

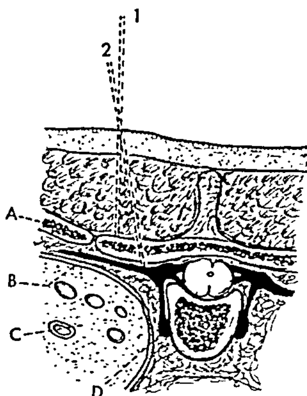



*Figure 42.* Method of introducing the needle for paravertebral block for anesthesia of the chest wall. (From "Nerve Blocks" by John Adriani, M.D., Charles C Thomas, Publisher, Springfield, Illinois.)

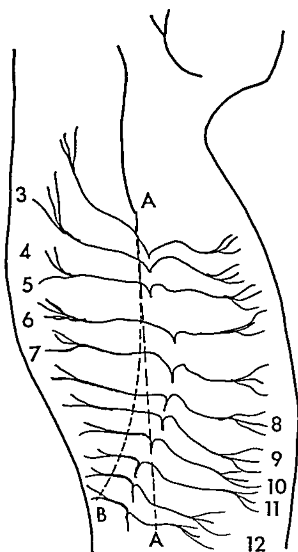



*Figure 41.* Intercostal nerve block. The lower intercostal nerves divide more posteriorly than the upper. Skin wheals should be raised along line *A–B* instead of *A–A*. (From "Nerve Blocks" by John Adriani, M.D., Charles C Thomas, Publisher, Springfield, Illinois.)

sired. Aspiration is done before injection of the drug since it is possible to direct the needle into the subarachnoid space, into a blood vessel or into the pleura.

*Lateral Femoral Cutaneous Nerve Block.* This nerve block may be used for superficial operations on the lateral aspect of the thigh, such as skin grafts and removal of tumors. The landmarks are the anterior superior iliac spinous process and the inguinal ligament (Fig. 43). The patient is placed in the supine position. An intradermal wheal is raised 1 cm. caudad and medial to the anterior superior iliac spinous process and an 8 cm. needle is introduced vertically through this wheal and advanced until the iliac bone is encountered. Ten cubic centimeters of a 1 per cent solution of procaine is injected. The needle is then withdrawn almost to the skin and injections, with additional 10 cc. of solution, are performed in a fanwise manner in the lateral medial direction over an area of 4 or 5 cm. along the spinous processes of the ilium.

*Femoral Nerve Block.* The femoral

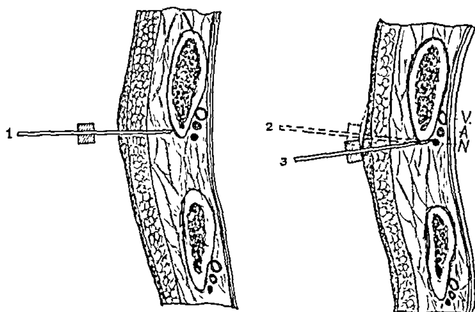



*Figure 40.* Technique for blocking intercostal nerves. The relationship of vein, artery and nerve is shown. (From "Techniques and Procedures of Anesthesia," by John Adriani, M.D., Charles C Thomas, Publisher, Springfield, Illinois)

5 cc. of a 2 per cent solution of procaine is introduced between the two fingers until the body of the vertebra is encountered. The solution is injected at this site (Fig. 39 *C*).

A successful stellate ganglion block results in Horner's syndrome, which is characterized by injection of the conjunctiva, miosis, enophthalmos and absence of sweating on the face and arm on the side injected.

*Block of the Intercostal Nerves.* The intercostal nerves may be blocked as they course the intercostal spaces. The usual landmarks are the midaxillary line and inferior border of the rib. With the patient in the upright sitting position and hands folded over the head to allow ample exposure of the thorax, intradermal wheals are raised over the lower border of the desired ribs in the midaxillary line. Five-centimeter needles are then introduced through the wheals until contact is made with the lower border of the rib. The skin and soft tissues in the region of the puncture are then retracted downward with the thumb of the right hand (Fig. 40). The needles are then inserted 0.25 to 0 5 cm. beyond the lower border of the rib. Paresthesias are usually felt if a needle encounters a nerve. Five cubic centimeters of a 2 per cent solution of procaine is injected at this site. It may be necessary to infiltrate the skin and subcutaneous tissues in the midaxillary line with a 1 per cent solution of procaine to block the nerve filaments which leave the nerve posterior to the site of block. It must be remembered that the intercostal nerve accompanies the artery and vein in the intercostal groove along the inferior border of the rib. The nerve is inferior to the artery. The vein is superior to both nerve and artery.

The lower intercostal nerves divide into branches more posteriorly than the upper. They, therefore, must be blocked at, or more posterior to, the posterior axillary lines (Fig. 41).

There are times, as, for example, when the ribs are fractured, when the classic intercostal block cannot be used. The nerve may then be blocked paravertebrally. The patient is placed in the lateral-prone position with the pathologic side uppermost. The full prone position may be used if it causes no discomfort to the patient. The spinous processes of the vertebrae are identified. *The spines of the thoracic vertebrae are* arranged in a shingle-like fashion so that the ribs and spines do not correspond in number. For example, to block the eighth nerve, the seventh spinous process must be identified. A wheal is raised

for operations on the leg and foot only when combined with femoral nerve block. The posterior superior iliac spinous process and the greater trochanter of the femur are located (Fig. 45). A line is drawn between these points and bisected. At this midpoint a line is drawn perpendicular to this iliotrochanteric line in a caudad direction for a distance of 3 cm. A wheal is raised at this point. A 10 cm. needle with a marker set for 6 to 7 cm. is then introduced perpendicular to the skin through the wheal. Paresthesia will be felt on the posterior

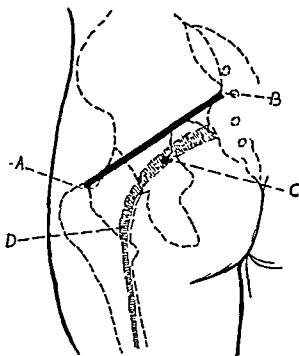



*Figure 45.* Method of inducing block of sciatic nerve *A*, Great trochanter, *B*, posterior superior iliac spinous process *C*, point midway between *A* and *B* 3 cm caudad. Needle is introduced at this point.

aspect of the leg and in the heel. Ten to 15 cc. of a 2 per cent solution of procaine is injected. Ordinarily a 2 per cent solution will not produce paresis and complete sensory anesthesia, and in certain instances as strong a solution as 4 per cent may be needed.

*Posterior Tibial Nerve Block.* Posterior tibial nerve block may be used for operations on the foot. The nerve may be blocked at the ankle. The landmarks for posterior tibial nerve block are the Achilles tendon and the internal malleolus of the tibia (Fig. 46). The leg to be blocked should be flexed and crossed over the other. The base of the internal malleolus is located and a line is circumscribed around the ankle which passes through this base. The Achilles tendon is palpated and the medial border marked; an intradermal wheal is then raised on the circumscribed line at the medial border of the tendon. The needle is introduced through the wheal and advanced perpendicular to the skin towards the tibia through the deep fascia and fat pad beneath the tendon until the second layer of fascia is pierced. Paresthesia is felt as the needle advances beyond this point. Five cubic centimeters of a 1 per cent solution of procaine is injected at this site.

*Anterior Tibial Nerve Block.* This block, when employed in conjunction with posterior tibial block, gives satisfactory anesthesia for operations on the foot. The landmarks are the internal malleolus and the tendon of the tibialis anticus muscle (Fig. 47). The patient is

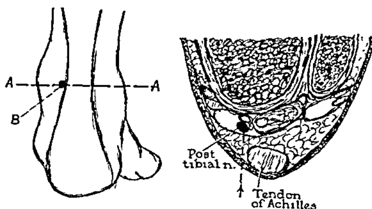



*Figure 46.* Posterior tibial nerve block. *A–A*, Line passing through base of internal malleolus. *B*, Site of wheal medial to border of tendon of Achilles (From "Techniques and Procedures of Anesthesia" by John Adriani, M.D., Charles C Thomas, Publisher, Springfield, Illinois)

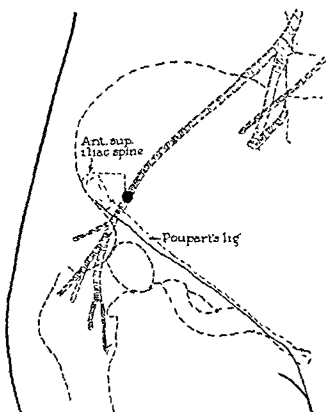



*Figure 43* Lateral femoral cutaneous nerve block Black dot is site of wheal medial and caudad to anterior superior iliac spinous process (From "Techniques and Procedures of Anesthesia" by John Adriani, M.D., Charles C Thomas, Publisher, Springfield, Illinois)

nerves may be blocked below the inguinal ligaments. This block may be used for operations on the anterior medial aspect of the thigh. When used *in conjunction with sciatic nerve block* it is suitable for operations below the knee and on the foot. Landmarks are the inguinal ligaments and the femoral artery. The patient is placed in the supine position. The inguinal ligament is identified, and the femoral artery palpated and retracted medially during the injection. An intradermal wheal is raised just below the inguinal ligament (Fig. 44) lateral to the artery and an 8 cm. needle is introduced through the wheal perpendicular to the skin until the iliac fascia has been pierced. The marker is adjusted to 1 cm. as soon as the needle has passed the fascia, and the needle is inserted 1 cm. beyond the fascia. Paresthesia will usually be felt in the thighs. Five cubic centimeters of a 2 per cent solution of procaine is injected. If paresthesia is not elicited, it may be necessary to inject 25 cc. of procaine in a fanwise manner in a perpendicular direction beneath the fascia and into the muscle.

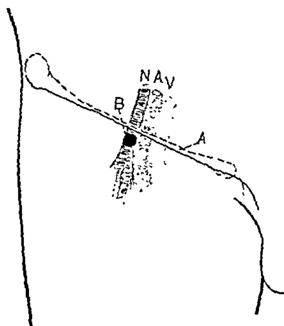



*Figure 44.* Femoral nerve block. *A*, Inguinal ligament. *B*, Site of wheal over nerve lateral to artery beneath ligament (From "Techniques and Procedures of Anesthesia" by John Adriani, M D, Charles C Thomas, Publisher, Springfield, Illinois.)

*Sciatic Nerve Block.* Sciatic nerve block may be indicated for fractures of, and operations on, the foot or later aspects of the legs. It is totally effective

dermal wheals are raised for each web on either side of the toe, and one at the extremity of each metatarsal space (Fig. 48). A 10 cm. needle containing a 1 per cent solution of procaine is introduced through the proximal wheal and injections are performed in a fanwise direction. The needle is then inclined toward the median sagittal plane of the metatarsal bone and 2 or 3 cc. of the solution is injected on the plantar surface of the metatarsal bone. This should be done through both distal wheals.

*Caudal Block.* Caudal block, or block of the lumbosacral and coccygeal plexuses, is obtained by depositing a solution of local anesthetic in the sacral portion of the epidural space. The nerves are bathed as they emerge from the dural sac, which terminates at the second sacral foramen. The capacity of the epidural space in the caudal canal normally is about 8 cc. More than this amount may be injected into the canal because the excess has diffused out along the nerves as they leave the intervertebral foramen.

To perform a caudal block the patient is placed in the prone position with a pillow under the hips in order to elevate the sacrum. The operator stands preferably on the patient's left side. With the right index finger at the base of the vertebral column the coccyx is palpated in the gluteal cleft. The sacrococcygeal joint is felt by drawing the fingers cephalad over the coccyx. A depression felt at the joint corresponds to the sacral hiatus (Fig. 49). The sacral cornua represent the inferior articular processes of the fifth sacral vertebra. The cornua mark the lateral boundaries of the sacral hiatus. The second foramen is next located by palpating the posterior superior iliac spinous process and indicating a point 1 cm. caudad and 1 cm. medial to the spine. This point overlies the foramen.

To perform the block an intradermal wheal is raised at a point midway between the cornua. This overlies the sacral hiatus. One and one-half cubic centimeters of anesthetic solution is injected into the subcutaneous tissues and sacral coccygeal membrane. The needle is next placed along the sacrum on the skin and the distance between the second sacral foramen and the cornu is marked off. The skin over the hiatus is stretched with the thumb and the index fingers of the left hand and punctured with a 10 cm. needle. The needle is grasped (with the stylet in place) with the thumb and the index finger and introduced through the wheal at an angle of 45 degrees to the skin overlying the sacrum (Fig. 50). The needle is then advanced to the sacrococcygeal membrane, which is encountered approximately ¾ cm. from the skin surface. The angle of the needle is then shifted to approximately 20 degrees with the surface of the sacrum. The sacrococcygeal membrane is then pierced and the needle is introduced into the sacral canal as far as the indicator or mark which was determined at the beginning of the block. The stylet is withdrawn, a 5 or 10 cc. syringe is attached and aspiration is attempted. The needle is rotated to an angle of 180 degrees and aspiration is attempted once again. If no blood or spinal fluid is obtained, 5 cc. of a 2 per cent solu-

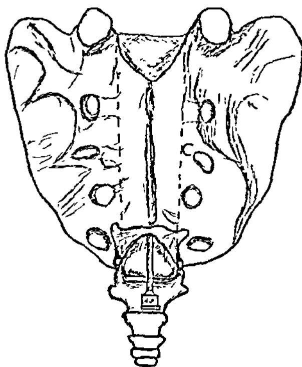


*Figure 49.* Dorsum of sacrum showing needle lying in canal at sacral hiatus between sacral cornua. (From "Techniques and Procedures of Anesthesia," by John Adriani, M.D., Charles C Thomas, Publisher, Springfield, Illinois.)

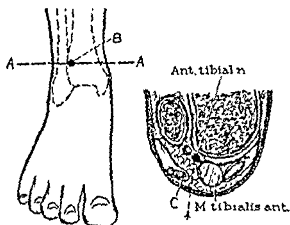
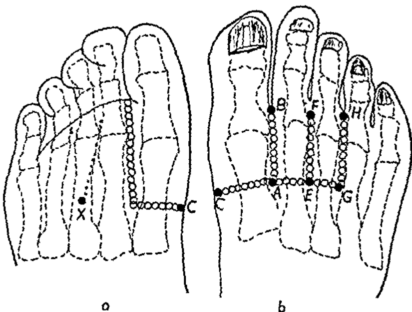



*Figure 47.* Anterior tibial nerve block. *A–A*, Line passing through internal malleolus. *B*, Site of intradermal wheal at lateral border of tibialis anticus *C*, Tendon of extensor digitorum longus (From "Techniques and Procedures of Anesthesia" by John Adriani, M.D., Charles C Thomas, Publisher, Springfield, Illinois.)

placed in the supine position with the leg flexed so that the sole of the foot rests upon the table. A line that passes through the base of the internal malleolus is circumscribed about the ankle, in the same manner as for posterior tibial block. An intradermal wheal is raised on a line lateral to the tendon of the tibialis anticus muscle. The needle is connected to the syringe and introduced through the wheal until it encounters the tibia. It is then withdrawn about 2 mm. and 5 cc. of a 1 per cent solution of procaine is injected into this area. The needle is then partly withdrawn and inserted in a lateral direction between the extensor hallucis longus and extensor digitorum longus tendons until the tibia is encountered. A 1 per cent solution of procaine is injected at this point.

*Block of the Great Toe.* The landmarks are the metatarsal bone of the great toe and the web between the great and the second toe. An intradermal wheal is raised at the dorsomedial border of the foot alongside the first metatarsal of the great toe (Fig. 48). An 8 cm. needle attached to a syringe containing a 1 per cent solution of procaine is passed through the wheal in a direction normal to the skin. The position is then changed to an oblique one when the skin has been pierced and a 0.5 per cent solution of procaine is injected in the interosseous space. The injection is repeated in a fanwise manner along the interosseous space. The needle is then introduced through the wheal over the web and the injection is repeated again in a fanwise direction.

*Block of the Toes.* As for the great toe, the webs adjacent to the selected toe or toes are used, and the proximal extremities of the intermetatarsal spaces of the toe or toes are selected. Intra-



ture is performed. Commercially prepared solutions of "heavy Nupercaine," Pontocaine or procaine are simpler to use.

The patient is placed in the upright sitting position. After the skin over the back has been prepared for lumbar puncture, an intradermal wheal is raised at the fourth interspace and the interspinous ligament is infiltrated with a 1 per cent solution of procaine. If this interspace is inaccessible, the third may be used. A 22 gauge spinal needle is then introduced and the solution is injected as rapidly as gentle pressure on the plunger permits. The needle is held firmly with the left hand while the injection is being performed. Upon completion of the injection the needle is promptly withdrawn and the patient is allowed to remain in the upright sitting position for sixty seconds, if true saddle distribution of anesthesia is desired. The glucose makes the solution heavier than spinal fluid so that it gravitates downward into the tip of the dural sac. The patient is then placed on a horizontal table in the recumbent position with his head supported on a pillow. If more diffuse anesthesia is desired, the patient is allowed to remain in the upright position for 30 seconds more. Hypalgesia and paresis then will be extended into the extremities. This distribution of anesthesia is desirable when the lithotomy, Sims and similar awkward positions involving the legs are to be used. When anesthesia is desired mid-way between the umbilicus and the pubis, as would be necessary for manipulation of the thigh and hip, the patient is promptly restored to the recumbent position upon completion of the injection. Estimation of blood pressure and pulse must be made and all other precautions observed for spinal anesthesia must be followed for saddle block. If hypotension develops, 25 mg. of ephedrine should be promptly administered intravenously followed by 25 mg. intramuscularly. Under no circumstances should saddle block be performed if an apparatus for administering artificial respiration is not available. The hazards, complications, and dangers pertaining to spinal anesthesia in general are applicable to saddle block.

## RESUSCITATION

Regardless of the simplicity of the operation undertaken, even in the performance of operations on ambulatory patients, in due time one is almost certain to encounter a situation requiring resuscitation. Therefore, anyone performing surgical procedures, irrespective of their magnitude, must be prepared at all times to manage both cardiac and respiratory arrest.

### Respiratory Arrest

Respiratory arrest is more common than cardiac arrest and is, as a rule, more successfully overcome. Fortunately, in most instances it precedes cardiac arrest. In surgery it usually is the result of overdose of an anesthetic drug. Unless promptly treated, respiratory arrest is quickly followed by circulatory failure and cardiac standstill. It is not uncommon then for one to be confronted with both emergencies simultaneously. The uninitiated, inexperienced physician usually becomes panicky when confronted with respiratory arrest and instinctively reaches for syringes, needles and ampules. The only treatment for apnea is artificial respiration instituted immediately by whatever method is available at the moment. Too often valuable time is wasted administering stimulants or waiting for mechanical resuscitators to be brought in. The object in apnea is to fill the alveoli with oxygen and to remove the carbon dioxide. Nothing one can administer with a syringe will take the place of oxygen. Once oxygen has been delivered to the alveoli, if the circulation is intact, it passes into the blood and is carried to the tissues. Life will be sustained temporarily, at least. If the circulation is not intact and the heart has stopped beating also, then measures for cardiac resuscitation must be instituted simultaneously and immediately. While this is being done, artificial respiration must be maintained without interruption.

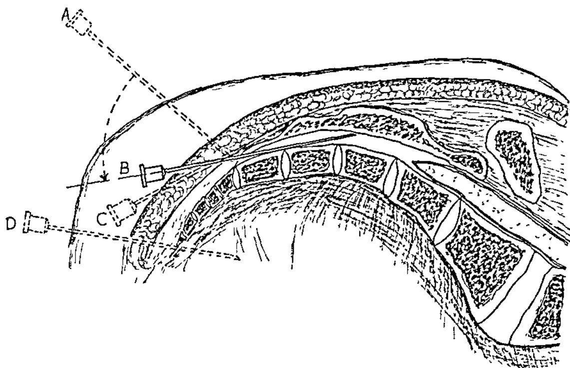



*Figure 50* Cross section through sacrum showing direction and manner of introducing needles in attempting caudal block *A*, Direction needle is first introduced to contact sacrococcygeal membrane. *B*, Needle in canal *C*, Incorrect placement, needle lying outside of canal superficial to sacrum. *D*, Incorrect placement; needle introduced at tip of coccyx into pelvis. (From "Techniques and Procedures of Anesthesia," by John Adriani, M D , Charles C Thomas, Publisher, Springfield, Illinois)

tion of procaine is slowly introduced into the canal. The solution should pass freely with slight pressure on the plunger if the needle is in the canal. The hand is placed upon the dorsum of the sacrum during the injection to detect tumefaction, which indicates that the needle is subcutaneous rather than in the canal The syringe is then removed from the needle and the stylet replaced. If toxic reactions or spinal anesthesia does not appear after 5 minutes, the remaining 20 cc of the 2 per cent solution of procaine is slowly injected into the canal. Aspiration should be done frequently during the injection. The needle should be withdrawn from the canal but not completely from the subcutaneous tissue It should be directed toward each cornu, first one side and then the other, and 0 5 cc. of solution injected at each cornu. This blocks the fifth sacral nerve, which emerges beneath the cornua. Anesthesia appears gradually within 10 to 15 minutes and lasts from 1 to 2 hours. It is distributed over the anus, structures over the sacrum, vagina, labia majora and minora, and the undersurface of the penis, scrotum, bladder (except the dome), the urethra, cervix and lower uterine segments. The muscles of the pelvic floor are relaxed.

*Saddle Block.* Saddle block anesthesia is a form of spinal anesthesia which affects principally the sacral spinal segments. In true saddle block, distribution of anesthesia is confined to the perineal area and is useful for urologic, gynecologic, rectal and other forms of surgical procedures involving areas of the body supplied by the sacral nerves. By modification of the saddle block technique the lower lumbar nerves may also be affected so that anesthesia may be extended to the thighs and to the area above the pubis. Selection of the drug used is based on the duration of anesthesia desired. Procaine (50 mg.) may be used if the operation requires 1 hour or less; tetracaine (Pontocaine) (50 mg.) for 1 to 2 hours; and dibucaine (Nupercaine) for 2 to 3 hours. The drug is dissolved in 1 cc. of a 10 per cent solution of glucose, drawn into a small syringe and held in readiness while the lumbar punc-




*Figure 51* Sylvester method of manual resuscitation.

tient's chest and compresses the lower anterior portion of the thorax with the elbows (Fig. 51*b*). The airway, of course, must be patent. The maneuver is repeated twelve to fifteen times a minute until a mechanical respirator is obtained. The Schafer method of artificial respiration, which was standard for many years, has been supplanted by the back pressure arm lift technique. In the latter method the subject is placed face down with elbows bent and one hand over the other. The head is turned slightly to one side and the face rests on the hand. The operator kneels on one knee at the head of the subject, facing him. The hands of the operator are placed on the back of the subject so that the thumbs touch and the heels of the hands are just below a line running between the armpits. Keeping elbows straight the operator rocks forward until the arms are approximately vertical. Steady pressure on the lungs forces the air out. The operator then rocks backward slowly, sliding his hands to the victim's arms just above the elbows to pull air into the lungs. He then raises the arms until resistance and tension are felt at the shoulders. Then the victim's arms are dropped and the cycle is complete.

Mouth to mouth breathing likewise is effective in the operating room. This is a simpler method of performing artificial respiration and is effective for short periods of time. No equipment is necessary. The airway is established and a pharyngeal airway or tube may be inserted, if available. The nose is pinched and the operator places his lips on the patient's lips and blows into the lungs. An exchange of 300 or 400 cc. fifteen or sixteen times a minute is thus established. Since this technique is quite tiring, one must resort to the use of an apparatus to supplant it, change operators or use another method.

A simple apparatus which is highly recommended for use in emergency rooms or physicians' offices is the Kreiselman resuscitator (Fig. 52). This consists of an accordion-like bag fixed to a mask.



*Figure 52.* The Kreiselman resuscitator.

In the *operating room* the simplest and most effective method of performing artificial respiration is to use the anesthetic apparatus as a resuscitator. The modern instrument is a closed apparatus. Essentially, it is a tight fitting mask connected to a breathing bag in such a manner that positive pressure may be made upon the airway. The mask is held firmly to the patient's face; the breathing bag is filled with oxygen and compressed manually. The lungs are inflated and the chest expands. When the hand is released, the pressure is decreased. The lungs, owing to elastic recoil, deflate and the thorax retracts. The cycle is then complete. This maneuver is carried on fifteen or sixteen times per minute. The method is used exclusively by anesthetists, is simple to teach and execute and is readily available in the operating room of every modern hospital. More lives are saved daily in the operating rooms throughout the country by this method of artificial respiration than any other.

No method of artificial respiration will be successful unless a patent airway is established. The commonest cause of failure at attempts at resuscitation is failure to establish an adequate airway. This is one of the most difficult things to teach a beginner. When artificial respiration is instituted in a comatose patient, it is advisable to insert a pharyngeal tube and hyperextend the head in such a manner that the chin points toward the ceiling. This maneuver elevates the structures of the pharynx and lifts the epiglottis, which is usually dependent and obstructing the larynx. Thus, a free airway is established. Intratracheal intubation is rarely necessary in resuscitation. In most instances, valuable time is lost in attempting intubation. Intubation is necessary only in the occasional patient whose chest is open, or in patients in whom it is impossible to establish the airway with a pharyngeal tube. A delay of 15 or 20 seconds may mean the difference between life and death. Therefore, no time should be lost in immediately instituting artificial respiration.

The blow and suck type of respirator (such as the E&J, the McKesson, and the Emerson), which is available in many operating rooms in hospitals, is satisfactory only in the hands of those familiar with resuscitative measures. In general, the results are disappointing because the inexperienced operator is unable to maintain a satisfactory airway and gas is sucked in and out of the mouth. This is evidenced by a succession of rapid clicks which indicates that the lungs are not being ventilated and the airway is not properly established. At other times nothing happens except that one hears a steady rush of gas. This is due to the fact that the operator is unfamiliar with the technique of holding the mask on the face and securing a tight fit. A pressure adequate for expanding the alveoli is never attained. A series of rhythmic expansions and deflations of the chest indicates that the apparatus is being used properly.

The iron lung is a most satisfactory device for artificial respiration, but it is not the method of choice for emergencies. Not only is it cumbersome but rarely is it immediately available. Besides, precious moments are wasted in readying the mechanism and placing the patient in the apparatus. It should be reserved for use in patients who do not respond to emergency measures and may require protracted periods of artificial respiration. If spontaneous attempts at breathing do not occur after 30 or 40 minutes of artificial respiration manually or by insufflation, then the patient should be placed in the iron lung.

The manual method must be used when other methods are not available but certainly is not the answer to the problem of successful resuscitation. In the operating room perhaps the most readily available and simplest manual method is that of Sylvester. In this method the patient remains on his back, the operator stands at the head end of the operating table, grasps the patient by the wrists and extends the patient's arms over the head (Fig. 51*a*). Expansion of the chest then takes place. He then returns the arms alongside the pa-

Chapter 5

# Physical Treatment in Minor Surgery

By Charles Long

Just as the engineer must know the properties of building materials, so must the physician know the properties of the methods he uses. Little emphasis is given in most medical schools to the building blocks of physical treatment, with the result that few physicians are equipped to write an intelligent prescription for this form of medical care. It is the purpose of this chapter to describe the physical methods available to the surgeon in the treatment of his patient, and to explain their application to the minor surgical conditions described elsewhere in this book.

## PHYSICAL TREATMENT METHODS

*Equipment and Supplies.* The amount of stationary equipment and expendable supplies necessary to the proper performance of physical treatment is astonishingly small. There are only two major requirements for excellent treatment: that the physician and therapist thoroughly understand the problem and the goals of therapy and that adequate physical space be available for the treatment to be carried out. Equipment within the space must then be adjusted to the specific problems handled in the clinic. It will always be of advantage to spend minimal amounts on equipment until the exact load for various items can be accurately predicted. It is a common mistake to provide too little space and too much equipment.

*The Prescription of Physical Methods.* As in other uses of ancillary personnel or facilities, the physician has complete responsibility for the patient throughout his physical treatment. He must write a complete prescription for the therapy and must follow the patient closely while he is receiving it. There are many ways of writing therapy prescriptions. It is quite permissible, often advisable, for each physician to adopt his own form of prescription writing. It is essential only that the therapist understand from the prescription exactly what is expected of her in treating the physician's patient.

*Therapeutic Exercise.* Therapeutic exercise has classic gradations from passive motion to resistive exercise. These gradations are made under the direction of the physician. In general, low resistance exercise, through a large number of repetitions, is helpful in the development of *endurance*. High resistance exercise, carried almost to fatigue, with a small number of repetitions, breeds *strength*. Power and functional use of a muscle group depend on the development of both of these factors.

PASSIVE MOTION. The therapist carries the prescribed anatomic segment through as full a range of motion as possible *without stretching at all.* Passive motion can be expected only to *maintain an existing* range, not to increase it. Prescriptions for passive motion should include an indication to the therapist of the amount of pain the patient may be expected or permitted to undergo during therapy.

PASSIVE STRETCHING. This is a treatment carried out by the therapist, without active help from the patient. The segment is to be stretched beyond the existing comfortable range. Prescriptions should include an indication of pain expected and an adjectival modification of the degree of stretch requested.

Example: "Twice daily moderate pas-

As the bag is compressed, the air is insufflated into the lungs; as the bag is extended it is filled with fresh air. The lungs contract passively and the exhalations pass out through a special valve. Thus, each impulse delivers fresh air to the lungs. No negative pressure is exerted upon the alveoli. The exhaled gas passes out through the valve passively.

### Cardiac Arrest

To be successful, cardiac resuscitation must be instituted without delay. Many attempts at cardiac resuscitation are successful but the patient ultimately dies after a period of time, because the circulation has been interrupted for so long that cerebral damage results. Even though the heart action is restored, the patient dies as a result of ensuing tissue anoxia. If the subject survives, he is left with serious neurologic sequelae and often impaired mental processes.

As soon as the diagnosis is certain, or one suspects that the heart has stopped beating, an incision should be made between the fourth and fifth ribs on the left side. Care must be exercised not to extend the incision too far medially toward the sternum, in order to avoid cutting the internal mammary vessel. The ribs are spread and held apart by rib spreaders. The heart is grasped in one hand and massaged forty to sixty times per minute, or as rapidly as the operator can massage it, if this rate cannot be maintained. Every ten or fifteen beats the aorta should be compressed in order to force the blood through the coronary vessels supplying nutrition to the heart. Too great intrathoracic pressure must not be exerted in doing artificial respiration during cardiac resuscitation, as it may interfere with the venous return to the heart. If the ventricles are atonic, 2 cc. of a 0.5 per cent solution of barium chloride or 5 cc. of a 5 per cent solution of calcium chloride may be injected into the heart to increase the tone. There seems to be some question whether or not epinephrine should be used, as it increases myocardial irritability and may possibly precipitate ventricular fibrillation If it is used, it should be used in the atonic and not the irritable heart and should be injected into the auricle on the right side, rather than the ventricle. It is not necessary to open the pericardial sac to perform cardiac massage. A less desirable method of massaging the heart is through an abdominal incision. The heart is thus not directly available and compression must be done by applying pressure behind the diaphragm.

If, perchance, when the chest is opened, instead of asystole one is confronted with ventricular fibrillation, cardiac massage is continued until a defibrillator can be obtained. Although restoration of cardiac rhythm is not possible until defibrillation is accomplished, adequate blood flow to the myocardium and cerebrum can be maintained only by cardiac massage. The defibrillator suggested by Wiggers utilizes an ordinary 110 volt, 60 cycle, alternating current. The instrument has sufficient resistance in the circuit so that the amperage is reduced to 1 or 1½ amperes. The current is passed through two brass circular electrodes about 3 inches in diameter which are applied to each surface of the heart. The organ is shocked for 0.10 second with 2-second intervals between shocks. Usually three to seven shocks will suffice for defibrillation. Before the shocks are applied, the heart should be massaged for 30 or 40 seconds in order to expel the blood from its chambers, because it is usually dilated when ventricular fibrillation has occurred. After defibrillation it usually is necessary to massage the heart because asystole results.

Neither highly specialized training nor elaborate equipment is required in most emergencies involving cardiac arrest. The chance of performing the procedure on someone who might have survived without massage must be accepted.

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mits the development of a "routine" method. In general the prescription of a "routine" (e.g., "start postmeniscectomy routine") is decried, since no two patients (or knees) are alike.

*Ambulation Training.* After minor surgery the patient rapidly regains his unaided walking ability, so that ambulation training here is for interim purposes only. The patient is expected to progress through a sequence of training methods, predicated on his existing, and improving, disability. Ambulation with support is used if the patient requires some weight-bearing limitation or if he is unable to balance properly for unsupported ambulation.

The use of well-taught crutch and cane gaits is not limited to the aftercare of fractures. These gaits are useful in any situation requiring careful grading of weight-bearing, as in incipient arteriosclerotic gangrene, or when balance is precarious, as after bed rest due to trauma.

PARALLEL BARS. The parallel bars are an excellent medium for instruction in early balancing procedures and in the development of a proper pattern of walking for later use on crutches (Fig. 54).

THE WALKER. The aluminum pipe walker, *without wheels,* is an excellent, stable supporting device for "rickety" patients. For the elderly patient or the patient with severe balance problems, crutches may be unsafe. The unwheeled walker provides a pair of portable parallel bars which the patient can lean on for unquestioned support. Its use may form an intermediate stage between parallel bars and crutches for some patients.

THE THREE-POINT GAIT. This is the most commonly used gait for the support of disability of a single extremity. It allows complete control of weight-bearing on the affected extremity, from simple non-weight-bearing and toe-touching to almost full weight-bearing. The two crutches and the affected extremity bear



Fig. 54.



Fig. 55.

*Figure 54.* *Rx:* "See the patient twice daily for instruction in three-point gait pattern in the parallel bars, with one-quarter weight-bearing on the right lower extremity. Give daily balancing practice in the bars. As soon as the patient understands the pattern and is safe in the bars, begin balancing and four-point training on bilateral wooden axillary crutches."

*Figure 55.* Three-point gait. Crutches and affected lower extremity bear weight simultaneously. Little weight is borne in the axillae.

sive stretching of the right knee into extension for twenty to thirty minutes; this may be done with patient face-lying, with increasing weights hung over the ankle at the edge of a table. Do not stretch through pain. Precede therapy with whirlpool at 100 degrees."

ACTIVE ASSISTIVE EXERCISE. In active assistive exercise both therapist and patient are assisting in carrying the segment through the existing range of motion. This type of exercise is used for the development of strength in muscles unable to move the part alone, or in the presence of pain which limits active motion by the patient. It does not imply stretching to increase the range, but may in itself increase range as treatment is continued.

SETTING EXERCISE. Nonresistive exercise of a muscle without joint motion is called "setting." It is commonly used postoperatively or in post-traumatic states to prevent muscle atrophy due to disuse at a time when segmental motion would be dangerous.

ACTIVE EXERCISE. The patient uses his own muscle power to move the segment, under the direction of the therapist. Gravity-eliminated or antigravity active exercise should be implicitly prescribed.

Example: "Twice daily active antigravity motion short of fatigue to the extensors of the right knee. Increased range of extension should be encouraged by vigorous effort on the patient's part at the extremes of range. Pain is expected at the extremes. Do not stretch passively."

ACTIVE RESISTIVE EXERCISE. The therapist resists the patient's active attempts at movement. Resistance may be given manually (manual resistive exercise) or by weights (weight resistive exercise)

PROGRESSIVE RESISTANCE EXERCISE. The use of this term should be restricted to a didactic method of exercise described by DeLorme. It is a method of increasing strength rapidly in muscles controlling a segment. It should not be prescribed unless the segment could sustain little damage from severe exercise. Since it is time-consuming and exacting, it should be prescribed only for a limited number of muscles or segments (Fig. 53).

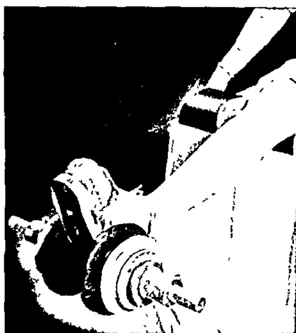


*Figure 53.* *Rx:* "Give daily progressive resistance exercise (PRE) to the right quadriceps. Teach the patient the proper method of doing this daily at home after her discharge from the hospital, and arrange to see her weekly for adjustment of weights after her discharge. Report immediately any swelling or increased pain in the knee. I will see the patient for review in six weeks."

GENERAL CONDITIONING EXERCISES OR POWER BUILDING EXERCISES. Prescription of this type of exercise implies a large number of groups of muscles to be strengthened as rapidly as possible by systematically graded increasing resistance (weights or manual). The gradation is left to the therapists' discretion. It is often used to develop upper extremity strength prior to anticipated crutch-walking.

Example: "Once daily power building exercises to the upper extremities in bed in preparation for crutch-walking. Because of patient's age, go slowly; use manual resistance only."

The use of fully worded prescriptions may be essential in assuring that the patient receives the expected therapy. Often these prescriptions may be made more telegraphic as physician and therapist become increasingly accustomed to each other's method of operation, or if a particularly common type of lesion per-

degrees of weight-bearing. The psychological advantage of "graduating" from woodens to Lofstrands cannot be overemphasized.

The Standard Wooden Cane. The standard wooden cane is only minimally useful. Because of its lack of wrist support, no significant amount of weight can be borne through it. It is useful primarily when the patient has minimal problems with balance alone, or when he is permitted almost full weight-bearing. The psychological support afforded by a wooden cane far exceeds the physical support. The three-footed "tripod" cane is only slightly more supporting, and still leaves the wrist unsupported.

*Occupational Therapy.* Occupational therapy is not available at all hospitals, and even where present it is often malused. Occupational therapy can provide the link between good surgical reconstruction and applied function of the extremity. Following surgical procedures, particularly of the hand, the patient is first sent to Physical Therapy for exercises to strengthen the hand and increase its range of motion. When significant function has been established in Physical Therapy, the patient may be referred to Occupational Therapy for use of the segment. The occupational therapist is trained to provide for the involved segment activities designed to increase endurance, mobility, coordination and dexterity (Fig. 57). Occupational therapy prescribed for any one of these purposes is called Functional Occupational Therapy. Occupational therapy can be used conveniently on an out-patient basis; frequent visits are not necessary since the occupational therapist can provide suitable activities for the patient to perform at home.



*Figure 57.* Functional occupational therapy is designed to increase dexterity, coordination, mobility or endurance of the affected part.

*Physical "Modalities."* The classic term "modalities" refers to all physical treatment measures which can be applied to the patient, usually by a physical therapist, and includes heat, massage, light, electricity and various forms of mechanotherapy. This method of treatment is included last in this discussion because it is indeed the least important portion of the pre- or postoperative prescription. "Modalities" usually form only an adjunct to the proper prescription of exercise and the proper guidance of the patient's general activity. Patients recover very well without heat; they do not recover very well without exercise.

HEAT. The principles of the proper application of heat are few and simple. Heat should *never* be prescribed to an anesthetized area nor to an area of jeopardized circulation. The only judge of the amount of heat a patient is receiving is the patient himself, regardless of the kind of heat used. In an anesthetized segment the patient cannot judge heat and will burn. In circulatory insufficiency, heat does indeed cause some vasodilation, but not in a great enough degree to supply the increased metabolic demand of tissue brought about by the same heat. Gangrene following the application of moderate heat to a decompensating extremity is *common.*

An important and common use of heat is as a preliminary to therapeutic exercises. Such preliminary heat increases the efficiency of the exercises.

Heat is prescribed as penetrating or nonpenetrating heat. Nonpenetrating

weight simultaneously (Fig. 55) permitting both arms to carry the load as the foot is placed. It is called "three point" because three points (two crutches and the affected extremity) are bearing weight simultaneously.

THE FOUR-POINT GAIT. This is a more stable, slow and supporting gait than the three-point. In the four-point gait, one extremity moves at a time; the other three are always firmly planted on the floor. The gait follows a reciprocal pattern; left crutch, right foot, right crutch, left foot. Complete control of the degree of weight-bearing on the affected limb is possible through the support of the other three limbs.

*THE TWO-POINT ALTERNATE GAIT.* This gait follows the pattern of normal walking. One lower extremity and the opposite upper extremity are moved simultaneously. Weight is borne on one leg and the opposite crutch. Since the patient must bear all weight on the single crutch and single foot, this gait is not applicable to the control of weight-bearing under one-half of full weight, and is not efficient under three-quarters. It is used only in the advanced stage of ambulation training when high speed of walking is desired and the limb is considered safe for almost full weight-bearing. It is a handy gait to use for the patient who is wary about increasing weight-bearing to the amount desired by the physician (as in dysunion of the distal tibia).

THE TRIPOD GAITS. These gaits are very rapid, and lose stability in relation to their speed. The crutches are moved together and placed ahead of the patient. The patient then swings both legs through the crutches to perform the classic "swing-through" gait. It requires excellent balance, and usually, therefore, a very young patient. It is the only gait that can be used if the patient is not allowed to touch even his toe to the floor on the affected side. Because of the basic instability of the tripod gait, every possible attempt should be made to provide the patient with some form of minimal "weight-bearing" on the affected extremity.

SINGLE CRUTCH (OR CANE) GAITS. When minimal balance problems exist, a single upper extremity support is permissible. Very little true weight-bearing support can be afforded by a single cane. For balance purposes the single cane is always carried in the upper extremity of the unaffected side and is moved in company with the affected limb.

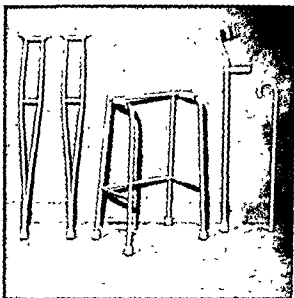


*Figure 56* Some commonly used ambulation supports wooden axillary crutches, aluminum pipe walker, Lofstrand cane, standard wooden cane.

CRUTCHES AND CANES. The patient should have that form of crutch or cane which is least unwieldy, but which will still provide adequate and safe support (Fig. 56).

Wooden Axillary Crutches. These are the safest mode of support, excepting the walker. They provide a portable resting place, allowing the patient to lean for support on his axillary rests if he becomes tired. Except for resting periods, no weight is borne in the axillae. The proper use of axillary crutches will make "crutch-paralysis" a fading phenomenon.

Canadian or Lofstrand Crutches. These crutches or canes include a family of supports designed to support the wrist joint. All have a cuff or sleeve which goes around the upper forearm. They do not support the elbow at all, nor do they provide as good a portable resting place as the wooden axillaries. They provide an excellent gradation for patients who have previously been on wooden crutches, and can be used for increasing

then should be gradually moved toward the patient in successive treatment periods. The modifying terms "gentle," "moderate" and "intense" may be used for infra-red (luminous heat) prescriptions (Fig. 59). There is practically no indication for "intense" heat.

The degree of heat in hot packs is not easily controlled. It is not a safe method of heat application for home use except with careful guidance. Special chemically regulated packs are available, but have little to offer above the benefits of properly regulated baths. Paraffin baths may be used, but provide a rather intense heat, above that necessary in most conditions. Heating pads are frankly dangerous; the heat controls are rarely well calibrated, and rather fantastic heat levels have been recorded from heating pads.

The diathermies are widely used, but the amount of use is in no proportion to the efficacy of the therapy. Diathermy is complicated, relatively dangerous, expensive and time-consuming in terms of physical therapist hours. It presents little significant advantage over superficial heating methods in the treatment of minor surgical conditions. It should never be used in the presence of metal foreign bodies (such as pins in hips) nor in the presence of acute inflammation or malignancy. Its propensity to intensification of pain and spasm in some traumatic back disabilities is well known. *It is safest for the general surgeon or practitioner to leave it alone.* Long wave diathermy has been outlawed by the Federal Communications Commission because of interference with communication media. Shortwave diathermy is now the most commonly used form. Microwave diathermy (a form of radar) is physically easier to apply than shortwave but carries the same risks.

MASSAGE. Massage is not complicated. Its effects are ill understood; they may be either soothing or stimulating depending on the depth of the massage. The place of massage in minor surgery is small. Sometimes light massage may be prescribed for the mobilization of edema, as during the activity stage after hand fractures. It may also be used for its soothing or relaxing effects after the application of heat in the treatment of minor muscular disorders.

### THE APPLICATION OF PHYSICAL MEASURES TO MINOR SURGICAL CONDITIONS

Physical measures applied judiciously by the surgeon and his associates may prevent needless surgery. These same measures used as a postoperative aid often spell the difference between success and failure of the surgical procedure.

It is a rare surgical case that prohibits preoperative orientation of the patient to his postoperative program. Such orientation enables the patient to try out his exercises prior to his surgery, when postoperative pain is not a factor. He then knows what he is expected to do postoperatively and responds much better in carrying out the later program.

The aims of a pre- and postoperative physical treatment program are few and simple. It is the purpose of these treatments to provide the involved segment with as nearly normal function as possible. This implies full strength and normal range of motion. It is implicit in physical medicine that treatment shall cause as rapid recovery of function as possible without causing harm to the segment. The naturally strenuous and potentially harmful character of physical measures must be borne in mind at all times. Just as the results of an operation can be markedly improved by physical measures, so can they be entirely ruined.

#### INJURIES

*Sprains and Strains.* Although the technical differentiation can be made between strains and sprains, common usage in and out of the medical profession has made the two practically synonymous; they will be so treated here.

Sprains involve damage to supporting tissue structures without significant rupture of fibers of these structures. They are notoriously painful, cause secondary limitation of motion due to protective muscle "spasm," and are often accom-



Fig 58.



Fig. 59.

*Figure 58.* *Rx:* "Give twice daily warm whirlpool to the right hand with gentle active underwater exercise to maintain range of the fingers in flexion and extension. Teach the patient to continue this therapy at home twice daily in the form of warm baths, and discharge automatically from guided physical therapy when the method has been learned."

*Figure 59.* *Rx:* "See the patient twice daily for moderate infra-red for twenty minutes to the posterior neck. Teach the patient how to use his own heat lamp at home for the same purposes, and discharge automatically from guided treatment when he has learned the method."

heat is the safer of the two types. There are extremely few instances in which "deep heat" or penetrating heat will provide a therapeutic result different from superficial or nonpenetrating heat, and the dangers of deep heat are great.

Nonpenetrating or superficial heat is applied by numerous methods: hot water bottles, paraffin baths, whirlpools, hot packs, infra-red lamps and heating pads. Because of its easy adjustability and extreme accuracy in temperature control, the whirlpool bath or tub soak is the safest method of application of heat. The effects of the heat are identical if applied in a complex whirlpool in the physical therapy clinic or in the wash-basin in the patient's home. The agitating effect of the whirlpool has minimal physiologic effect; its main effect is to keep the water circulating, thereby preventing the body part from cooling the water in its immediate vicinity. Warm baths or whirlpool treatment (Fig. 58) may be prescribed with the modifying terms "body temperature," "warm" or "very warm." These correspond roughly to temperature ranges respectively of 95 to 99 degrees, 100 to 105 degrees and 105 to 110 degrees. There are few indications for the prescription of "very warm" whirlpool or baths.

Next in safety after the water baths, and excellent in efficacy, is the infra-red lamp. Distance from the patient is the major controllable feature. Never prescribe a specific distance for the therapist to use, for all patients and all lamps are different. Explain to therapist and patient the amount of heat you expect him to feel.

The therapist will know, and the patient should be instructed, that the lamp should first be put at a distance which produces less than the desired effect,

larly beneath the support to prevent disuse atrophy. Quadriceps setting and deltoid setting are examples.

*Contusion.* Contusion is a minor but annoying injury. Resultant ecchymoses may limit muscle function and are sometimes cosmetically annoying. After the first 24 hours, during which ice packs may be used, the patient should be encouraged to use the segment in normal fashion. For the rapid resolution of cosmetically annoying contusions, once daily shortwave diathermy of moderate intensity for 30 minutes may produce excellent results.

*Hematomata.* Hematomata can be helped in their resolution by the measures outlined above for contusions. Greater care should be taken in the acute phase to avoid recurrent hemorrhage. Four to seven days' waiting period is advised before the application of heat and the encouragement of normal use of the part.

*Fractures.* Re-establishment of normal bony continuity is the major goal of fracture therapy. This goal can often be met without great sacrifices in strength and range of motion of the segment. The minimal number of joints consistent with stabilization of the fracture should be immobilized. All unimmobilized joints in the involved extremity should be exercised actively throughout the course of immobilization. Early active motion of the affected segment should be started as soon as immobilization is finished. Partial support of the affected part can be continued during therapy by using bi-valved casts for the first days or weeks after exercise is started. The whirlpool bath makes a convenient starting place for postimmobilization exercises. Early transfer to home treatment, either dry or in a tub or basin, will save time and money for therapist and patient.

Except in extreme cases, *passive stretching should never be used in the mobilization of an injured part.* Active exercise allows the patient to stretch his own joints within a pain tolerance dictated by a very knowledgeful central nervous system.

Certain fractures, particularly those of the tubercles of the humerus or the trochanters of the femur, when nondisplaced, permit immediate active motion. During the early phase of exercise treatment the part should be positioned to eliminate the effect of gravity. Gravity effects and the addition of weights are saved for later.

In discontinuous fractures of the lower extremity, weight-bearing may be graded by the use of crutch gaits as previously described. When a "walking cast" is applied, a lift should be provided for the opposite extremity to compensate for the length of the weight-bearing attachment to the involved limb.

*Whiplash Injuries.* Recent medical literature is replete with discussions of whiplash injury. The lesion has become a point of contention in many legal suits, and its "compensationitis" aspects cannot be minimized. Whiplash injuries are the result usually of a sudden extension injury to the neck, such as that received when a standing vehicle is struck from the rear. However, whiplash may also be sustained in flexion; when this occurs, dislocation and spinal cord injury are more likely.

The exact pathologic change in uncomplicated whiplash is unknown. The symptoms are typical, with a characteristic delay of several hours or days before the patient exhibits a syndrome which includes aching pain in the neck accompanied by some stiffness of the neck and often headache, with radiation of pain across the shoulders and down the lateral arms. Early treatment of this syndrome almost invariably meets with success. Unfortunately, patients and physicians will allow these symptoms to persist for weeks or months before treating them physically.

Early treatment of the uncomplicated whiplash consists of the thrice daily application of hot packs or infra-red, followed each time by active, full range of motion exercises for the neck in rotation and in flexion. There is no indication that such exercise can be detrimental, and it is essential to prevent permanent loss of range of motion of the neck. If

panied by extravasation of blood with hematoma or ecchymosis formation.

The typical physical treatment of a sprain is exemplified in the ankle sprain. For the first 24 hours heat should not be used because of the danger of increasing extravasation. The application of ice packs two or three times for 20 minutes each during the first day may be helpful. Thereafter, hot packs or hot soaks may be used twice daily, if adhesive support has not been applied to the ankle. Heat should not be used with adhesive because of the danger of burns beneath the adhesive; if it is used at all, it should be gentle and dry (as minimal infra-red).

Early use of the sprained ankle is essential to recovery. Immediate ambulation is the usual rule, with or without adhesive support. In severe sprains a three-point gait on crutches may be used to limit weight-bearing for a few days only. Early infiltration of the sprained area, at the point of maximum tenderness, may assist in getting the patient started, but is often unnecessary. Ten cubic centimeters of 1 per cent procaine hydrochloride is not a large dose in ankle sprain; it is the standard used by this author in all injections mentioned in this chapter, unless otherwise specified.

The protective positioning assumed by the ankle during walking after sprain may cause long-lasting limitations of motion, particularly in plantar flexion. The patient should be encouraged to stretch the ankle through full range of motion several times twice daily, as soon as the surgeon feels that no tissue danger is incident to this exercise. The patient can be instructed to stand with his back against a wall and to move his feet gradually away from the wall, keeping them flat on the floor, stretching the ankle into plantar flexion. He may stop this exercise when the sprained ankle reaches the range of the normal ankle.

In recurrent sprains it is important to develop musculature about the segment to prevent further sprains. Athletes are often prone to recurrent sprains because they use prime moving muscles to the detriment of supporting and stabilizing muscles. In recurrent ankle sprain, progressive resistance exercise (PRE) should be given to the evertors of the foot after the acute episode has subsided. This exercise should be continued by the patient until he reaches a plateau of strength; this strength will be above the measured strength of the normal side.

*Dislocation.* This is by far a more serious injury than a sprain. Supporting structures have been ruptured; time must be allowed for repair of these structures before therapeutic exercises are begun. The resting time must be determined by the surgeon. The patient then begins a gradation of exercise from active assistive to active resistive, in order to increase the strength and range of motion of the segment. During the acute phase, or resting phase, heat may be applied to the dislocated joint for the relief of pain, though again the danger of hemorrhage prevents such treatment during the first 24 hours. Heat should also be used prior to therapeutic exercises as a method of "warming up" the muscles.

Progressive resistance exercise is particularly important in the prevention of recurrent dislocation. Key muscles should be chosen for such therapy, such as the deltoid at the shoulder. Care should be taken in exercises to avoid the motion which originally caused the dislocation, until absolute integrity of the supporting structures is assured either by open surgical repair or the elapse of sufficient time.

*Ligamentous Rupture.* Ruptured ligaments must be treated with the same respect as dislocated joints. An early period of stabilization of the part is necessary. Following this, the same regimen of exercise is used as would be applied to a dislocated joint. Follow up by intensive, carefully chosen PRE is essential. This is particularly true of the knee, where the quadriceps expansion can serve as an excellent, accessory support of the knee after ligamentous damage. In most injuries involving immobilization in plaster or bandages it is advisable to have the patient "set" his muscles regu-

geon is quite qualified to handle these problems in most cases, but psychiatric aid should not be shunned.

*Burns.* Even "minor burns" may result in major losses of function if they involve critical segments, such as posterior knee, axilla or hand. Certain principles must be known to the surgeon for application prior to the institution of physical measures, if best functional results are to be obtained. Early skin cover is essential. A balance must be achieved between this early cover and the equally important necessity for early motion. Also, proper "functional positioning" of the affected part is essential to later use of the part. The part must be positioned to allow healing at the greatest possible length of involved structures, yet also to allow proper function of the part should inadvertent limitation of motion occur due to healing. The accompanying table shows suggested positions of immobilization, based on these principles.

Care must be taken not to cause damage during immobilization after grafting. Peroneal palsy from pressure over the fibular head is not uncommon after prolonged pressure dressing of the legs.

Early active exercise is the *sine qua non* of functional treatment in burns. This may be started "dry" or underwater in the whirlpool or the patient's hand basin or bathtub. Active exercise is used at first, with vigorous passive stretching added later to stretch resistant contractures. Passive stretching should be avoided in the hand, where joint swelling often follows such attempts. Functional use of the part for daily activities should be encouraged early, sometimes before skin cover is completed. The patient must be convinced that the degree of his recovery will be related directly to his own active efforts to exercise the part.

*Ruptured Meniscus.* Conservative treatment of the ruptured medial meniscus can obviate operation in many patients. Reduction of the meniscus may have to be accomplished by manipulation. This is followed by several days of thrice daily heat and gentle active exercise. The patient may bear weight on the limb if it is painless enough; crutches or canes are used as indicated. When pain subsides, heat is discontinued and active, antigravity exercise is begun daily in the sitting position. After two or three weeks, PRE should be started and continued until the strength of the involved quadriceps reaches that of the normal side.

Following operative intervention for ruptured meniscus, a graded exercise program assures a stable knee. It must start as quadriceps setting within two or three days after surgery. Setting should reach a maximum of 25 repetitions per hour during the day. When pain and swelling have subsided, gentle active exercise may be started. By the time sutures

Preferred Positioning in Burns

| *Joint* | *Position* | *Rationale* |
|---|---|---|
| Trunk and hips | Anatomic | Prevent scoliosis or flexion contracture of hips. |
| Elbow | About 40 degrees | Prevent flexion contracture.<br>Prevent extension contracture. |
| Knee | 5 to 10 degrees | Prevent flexion contracture.<br>Allow weight-bearing. |
| Ankle | Anatomic | Prevent dorsi- or plantar flexion contracture. |
| Wrist | 20 degrees extension | Prevent flexion contracture.<br>Allow good grasp. |
| Thumb | Full web space.<br>Thumb tip opposite index. | Prevent web space closure.<br>Allow opposition. |
| Finger | MP and IP at 15 degrees.<br>MP at 90 degrees.<br>PIP at 45 degrees.<br>DIP free. | Prevent flexion contracture.<br>Prevent collateral shortening.<br>Allow central slip healing.<br>Not significant. |



*Figure 60* Whiplash injury. Sayre sling traction is used for therapy in many whiplash injuries A suggested complete regimen for care of this injury is outlined.

PHYSICAL TREATMENT OF WHIPLASH

Early. Heat only for first twenty-four hours. Then heat three times daily, followed by active range of motion in rotation and flexion.

Subacute Heat twenty minutes twice daily, followed by neck traction in sitting position with *active rotation exercises* while in traction.

| | First three days | Second three days | Third three days |
|---|---|---|---|
| 1st 5 minutes | 5 lbs. | 7 lbs. | 10 lbs. |
| 2nd 5 minutes | 10 lbs. | 12 lbs | 17 lbs. |
| 3rd 5 minutes | 15 lbs | 20 lbs | 25 lbs |

Chronic Continue heat twice daily, followed by top level traction. Add slowly deepening massage once daily. Attack psychic elements vigorously; get suits settled. Prevent recurrent visits to therapist by insisting on home therapy. Recheck cervical x-rays if diagnosis in doubt.

symptoms persist after a few days of this treatment, neck traction should be added. This may be given first on a daily basis in a physical therapy clinic. After the first three or four such treatments the patient may be provided inexpensively with his own traction apparatus, to be used twice daily at home in the sitting position, preceded by infra-red or hot packs given prone. Weights used in traction for whiplash should not exceed 25 pounds and are given in 5-minute periods of increasing weight. The accompanying chart (Fig. 60) shows the progression of procedures used in whiplash. In the event of nonresponding pain, deep massage may be added. Massage should always be started gently and increased in depth with the tolerance of the patient. Aspirin in doses of at least 45 grains per day should accompany physical treatment.

The importance of psychic elements cannot be overemphasized. Whiplash is unquestionably accompanied by demonstrable organic changes, such as limitation of motion, but often provides the neurotic patient with an excellent weapon for the attainment of secondary, subconscious gains. The general sur-

to 10 minutes of fairly low intensity current is adequate to drive the histamine ions into the superficial tissues. This treatment is given daily or three times weekly by the physical therapist; it should be successful within five to eight treatments if it is going to work at all. Its effectiveness is equal to that of surgical intervention, if there is no anatomic restriction of motion, such as evidenced by "clicking" in a De Quervain's syndrome. Following the removal of immobilization, the patient is instructed in gentle, underwater, mobilizing, active exercises to return range of the part to normal. The immobilization at the wrist can be well performed by a simple plaster half-shell, and at the ankle by a 90 degree posterior-stop short leg brace.

*Neuromuscular Disorders. Herniated Nucleus Pulposus.* Most herniated nuclei are treated conservatively with success. In lumbar disks, in the presence of persistent, demonstrable muscle weakness or pain plus reflex deficit, operation is indicated.

Most lumbar disk patients present themselves to the physician with acute back pain, traumatic or "spontaneous," accompanied by positive straight leg raising signs, severe extensor spinae spasm and limitation of spinal motion. Rest is a *sine qua non* in early conservative management. The patient should be put to bed in whatever position is most comfortable to him, and left there, without bathroom privileges, for several days or weeks. Hospitalization may be necessary to accomplish this without family interference. The Williams position, with hips and knees flexed, supine, trunk partially elevated, seems comfortable for most patients. A jointed bed board is available in hospitals and should be used under the mattress. Bed boards should be provided for all patients with chronic back disease treated at home. Heat may be applied in bed for symptomatic relief. Diathermy should be avoided. Salicylates should be used copiously; codeine is permissible in the early days.

Mobilization of the patient is critical. It is best to be extremely gentle about the mobilization process, for overzealous treatment can cause more damage than leaving the patient alone. Bathroom privileges can be first added, then meals out of bed, then ambulation about the house, followed by a gradual return to work. Heat is continued at twice daily intervals until symptoms are gone. Salicylates should overlap symptoms by several days. The effectiveness of any form of traction in the treatment of lumbar disk is unproved by controlled studies.

When the patient is free of symptoms, he still will likely have limitation of back motion. He should be started on gentle bending exercises in the direction opposite the limitation, starting with one repetition a day and adding one repetition until a limit of about fifteen is reached. Gentle spinal extensor antigravity active exercise may be started on the same formula. Neither exercise should be stopped until the back is normal.

Cervical disks present a more serious problem. Because of the paucity of space in the cervical canal, small herniations result in large neurologic deficits, and the danger of paraplegia is ever present. Intermittent or continuous neck traction should be given to the recumbent patient during the acute phase. If pain and neurologic deficits are resolving well, the patient may become ambulatory with a supporting felt collar and may receive neck traction at home twice daily as outlined for whiplash injury. Surgery may be carried out on indications similar to those for lumbar disks, but the dangers of cervical disk surgery, especially paraplegia, must be borne in mind. Heat, salicylates and a graded mobilization program are used as in lumbar disk.

*The Myofascial Pain Syndromes.* Myofascial pain syndromes produce pain in the affected muscular or supporting tissue areas or referred pain following sclerotomal reference patterns. They are due to an as yet undescribed pathologic change in the involved tissues and are identifiable by limited or extensive tender areas of muscle or supporting structures, with or without muscle tightness and spasm. These syndromes present a difficult differential diagnosis when mim-

are removed the patient may put the leg in a whirlpool and begin twice daily active flexion and extension. When flexion reaches 90 degrees weight-bearing is increased to tolerance and the patient starts antigravity quadriceps and hamstring exercises, followed as rapidly as tolerated by PRE (Fig. 53), bringing the involved quadriceps to the level of the normal one before stopping therapy. This may take two or three months.

*Diseases. Affections of the Shoulder.* In spite of the theoretical and academic advantages of accurate pathologic diagnosis in minor shoulder lesions, the physical treatments of most affections of the shoulder are strikingly similar. The various entities of subdeltoid and subacromial bursitis, supraspinatus and long biceps tendinitis, or glenohumeral periarthritis require much the same treatment.

Principles of shoulder management are simple. We seem to have spent so much educational effort teaching early motion in shoulder lesions that we have forgotten completely the salutary effects of rest. Rest must be balanced with exercise. A sling is not an heretical method of treatment and may be quite useful in early treatment provided the patient is instructed to perform pendulum exercises of the Codman variety in the sling. This rest period in the acute shoulder should last only a few days. Thereafter, shoulder mobilization must be stressed religiously. Heat should be given at home two or three times daily, using infra-red or hot packs. Heat is followed on each occasion by pendulum exercises and by exercises against gravity in all directions slowly increased as the lesion heals. The patient may be given specific instructions to walk his fingers up the wall to the maximum possible distance three times daily, or may be given instructions for a home shoulder exerciser (Fig. 61).

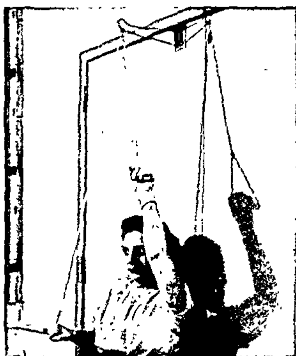


*Figure 61.* The patient may give self-administered passive stretching to the shoulder by this simple pulley device.

The adjunctive use of salicylates is essential in controlling shoulder pain. Procaine injection seems to be enhanced by the addition of about 50 mg. of hydrocortisone suspension or an equivalent amount of other anti-inflammatory steroid. The essence of this injection is to *put the solution where the pathology is;* for such treatment, accurate diagnosis is essential. Repeated injections are not usually needed if the first one strikes home. Considerable postinjection pain may be experienced and sometimes requires codeine or ice packs for relief.

*Tendinitides.* Tendinitis in areas other than the shoulder is usually a responsive illness to treat; this was true even before the advent of steroids. Immobilization during the acute phase, a few days to two weeks, is essential if the tendon is expected to heal cleanly. Resolution of the process may be hastened by the injection of hydrocortisone suspension, mixed with local anesthetic, into and around the tendon sheath. This author has met with success, in an uncontrolled group, by the use of Imadyl ion transfer over the affected area in superficial tendinitides. Imadyl Unction is applied over the affected segment, usually the tibialis anterior at the ankle or the long thumb abductor and short extensor at the lateral wrist. A moist pad electrode is then placed over the ointment and connected to the positive pole of an appropriate direct current source. Five

to 10 minutes of fairly low intensity current is adequate to drive the histamine ions into the superficial tissues. This treatment is given daily or three times weekly by the physical therapist; it should be successful within five to eight treatments if it is going to work at all. Its effectiveness is equal to that of surgical intervention, if there is no anatomic restriction of motion, such as evidenced by "clicking" in a De Quervain's syndrome. Following the removal of immobilization, the patient is instructed in gentle, underwater, mobilizing, active exercises to return range of the part to normal. The immobilization at the wrist can be well performed by a simple plaster half-shell, and at the ankle by a 90 degree posterior-stop short leg brace.

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icking cervical or lumbar neurologic lesions or thoracic and abdominal visceral lesions. The syndromes include "indurative" headache, tension neck, scalenus anticus syndrome, scapulohumeral syndrome, scapulocostal syndrome, the anterior chest wall syndromes, the anterior abdominal wall syndromes, "lumbago," the piriformis syndrome and several syndromes related to muscles of the lower extremities. They are characterized primarily by aching pain, muscle stiffness after disuse, occasional limitation of motion, temporary relief of stiffness by activity, increased pain and severe fatigue after the day's activities, worsening in changing weather, and responsiveness to salicylates and usually to steroids.

Space does not permit separate discussions of these syndromes. Myofascial pain syndromes respond to a judicious combination of rest and activity of the affected part, accompanied by continuous administration of salicylates. Stretching exercises are essential, but must be added gradually. Stretching of the neck is done by cervical traction, of the shoulders and lower extremities by stretching exercise of appropriate muscles, of the thorax by deep breathing, and of the abdomen and back by bending. Strengthening exercises are used if demonstrable weakness has occurred due to disuse; such exercises are added very gradually.

Adjunctive injections of "trigger areas" with procaine-hydrocortisone suspension is often helpful. The beneficial effects of procaine injection in the scalenus anticus syndrome is doubtless due to its essential character as a myofascial pain syndrome; only late does one see neurologic secondaries in this syndrome. Injections in myofascial pain syndromes are not without danger; they are inherently painful, and if given to an hysterical patient may serve only to fix his neurosis. Psychogenic factors are great in most myofascial pain syndromes and should be thoroughly explored with the patient.

These syndromes present one of the few definite indications for massage. At some stage, after the acute phase, massage is often used. Massage should start gently and gradually increase to a rather traumatic depth, with the ostensible aim of "ironing out" the tight or nodular areas of the involved muscles. After a few treatments by a registered physical therapist, the patient may receive massage from a family member who has been taught to perform this function daily by the therapist. The only exception is the piriformis syndrome, in which intrarectal massage of pelvic floor musculature must be carried out by the physician.

*Bell's Palsy.* Bell's palsy is a common affection, the outcome of which is probably determined by factors not significantly influenced by any treatment. Reports exist on treatment by facial canal decompression, steroids and stellate ganglion blocks without impressive controlled proof of effectiveness. The electromyogram can usually give a true prognosis. There is no proof that electrical stimulation to the facial muscles results in any greater or more rapid recovery than does no treatment at all; it is often helpful on a thrice or twice weekly basis as therapy for the psyche of patient and physician.

The Bell's palsy patient overuses his unaffected side and may stretch his affected muscles out of shape, so that poor alignment of the mouth results if recovery is only partial. The patient must be taught to hold the affected corner of his mouth when laughing or grimacing. Adhesive or Scotch tape support may be applied to the affected side running from the temple to the corner of the mouth.

*Root Compression Due to Cervical Osteoarthritis.* Even in the presence of neurologic deficit, this is an astoundingly responsive disease. Cervical traction should be given daily, in the clinic and then at home, with weights and progressions similar to those described for whiplash injury. The traction is preceded by heat given in the prone position. After relief of symptoms and signs, mobilizing exercises should be given for the cervical spine in the direction opposite the limitation.

*Peripheral Vascular Disease.* The

proper use of physical treatment in peripheral vascular disease is restricted to a very few measures under limited circumstances. There has never been substantial proof that any physical "modality" significantly alters the course of any vascular illness beyond the change due to the cleansing effect of some methods.

The primary method of care of peripheral arteriosclerosis, with claudication, ulcer or early gangrene, is cleanliness. Regular, warm (not above 95 degrees) baths with a mild detergent are indicated. Warm, clean socks, well-fitting shoes and proper care of the nails are essential. If significant color changes occur on dependency, the patient may be instructed to keep his legs elevated for stated periods during the day and to wear elastic stockings. If ulcer is present, whirlpool may be used for débridement, gently and below 95 degrees; detergent added to the whirlpool may help. Whirlpool is generally not used for isolated gangrene, since dry separation is desired and some maceration may follow whirlpool. The application of heat above 95 degrees causes stimulation of tissue metabolism out of proportion to the responding blood supply; *such heat is dangerous and should never be used.*

Because of their poor controllability, heat cradles, hot water bottles and electric pads are to be decried. The feet can rest comfortably under a foot cradle, to hold the weight of the blankets off the toes, and can be covered by wool blankets.

The ulcer due to varicose veins may also be treated by whirlpool as above. However, this is again only a cleansing measure and has no specific therapeutic effect. Support of the venous circulation by elastic stockings or bandages is the primary conservative method of care.

*Decubiti.* Decubiti were formerly known by the less euphonious term "bed sores." The continued use of this name would help to keep in the physician's mind the true nature and treatment of the condition. Decubiti result from continued pressure over areas of decreased tissue resistance, and their treatment is the relief of this pressure. This is done by frequent turning or by positioning in special attitudes by using pillows or sandbags.

The bed sore should be kept dry. Simple exposure treatment is the best way to serve this end. When exposure is not possible, fine mesh gauze will prevent sticking of dressings. Lamps of all kinds are avoided by this author in the treatment of bed sores; circulation is always jeopardized in the region of such a lesion, and heat is as likely to cause necrosis as desiccation.

Sometimes, if a decubitus is massive, débridement daily in the Hubbard tank at 98 degrees (95 often leaves the patient chilled) may allow granulations to form. This is not a substitute for the removal of pressure or for good surgical débridement.

*Backache.* Treatment of chronic backache is time-consuming and tedious, but often rewarding. Tenacity and flexibility in moving from diagnosis to diagnosis and treatment to treatment are essential.

Removal of the underlying cause is of first importance, if the cause can be found. Modifications of occupation, relief of psychic stress and changes in home routine are common, necessary adjuncts.

Tight segments are identified, with particular reference to heelcords, hamstrings and the back itself. Stretching exercises are given for the gradual relief of these tightnesses.

In the "chronic back" the physician can often identify weakness of muscle groups controlling the spine. Kraus has described a rapid method of testing and grading the essential muscles. When the weak segments have been identified, a graded strengthening program is instituted. The physician must be quite patient during this exercise program, for its beneficial effects may be two or three months in appearing.

External support for the back is most often unnecessary. The above exercises are usually adequate to support the back. A temporary support should be removed as early as possible, for its very presence allows disuse of back musculature.

Heat, massage and manipulation have

long been associated with treatment of the chronic back. These methods treat the symptom only and often represent a crutch upon which patient and physician are leaning. Heat and massage should be used sparingly; the use of these modalities should be put in the hands of the patient and his family as soon as possible, to lessen the danger of addiction to physical therapy given in a hospital setting. Coupled with salicylates in generous doses, these methods may prove excellent therapy in tiding the patient over periods of increased symptoms

### CONCLUSION

The proper application of physical treatment to the postoperative patient may make the difference between success and failure of minor procedures. It is essential that the physician and therapist have a clear understanding of the patient's limitations and potential goals. Specific, fully worded therapy prescriptions are important in developing this understanding and assuring a successful outcome of treatment.

Physical measures may on occasion obviate operation and thereby form a basic *part of the surgeon's preventive armamentarium.*

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*Chapter 6*

# The Surgical Resident

*By Frederick Fitzherbert Boyce*

## THE ACT OF OPERATION

The sort of education and training that the present-day medical student receives is a relatively recent development. Almost up to the turn of the century training for a medical career, at least in most medical schools in the United States, consisted in little more than five or six months of didactic lectures given for two or, at most, three years. Many schools had no laboratories. Those that possessed them used them infrequently and inadequately. Contact with patients in the undergraduate years was practically nonexistent. Many graduates went directly from medical school into practice, with no intervening period of hospital training or of apprenticeship to a more experienced physician.

The almost incredible situation that prevailed in medical education as late as 1893 is well described in the C. Jeff Miller Memorial Lecture[1] read by Dr. Miller's brother, the late Hilliard E. Miller, before the Southeastern Surgical Congress in 1942. It was not until 1910, in fact, with publication of the Flexner report, that medical education in this country began to take on some semblance of what it is today. Another quarter of a century was then to pass before the medical schools were thoroughly reformed and before hospital residencies began to be the rule rather than the exception in the training of the young surgeon.

Today the physician who enters upon a surgical residency has behind him a long period of study. The premedical course is always three years, and is usually four years. The four years of medical school are spent in graded and chiefly specified studies, with perhaps some opportunity for elective work in the final year. The intern year is sometimes spent on a rotating surgical service, with part of the time devoted to the surgical specialties. More often it is spent on a general rotating service, in which surgery occupies only part of the time. However it is spent, it brings the young physician into what might be called his first authoritative and responsible contact with patients and his first real practice of clinical medicine.

A great deal of confusion and misunderstanding would be avoided if the surgical resident could be made to realize that in spite of his advancement up the surgical ladder, he is still "a man under authority." That is true of all aspects of his residency, and is particularly true of the operative aspects. No physician, when he graduates from medical school, is capable of performing even the simplest surgical procedure, and he receives little technical training during his internship. This may be an unpalatable truth for the surgical resident to face, but in all honesty it must be stated, and stated emphatically and first of all, by anyone who undertakes to write a chapter dealing with the general aspects of a surgical residency.

The surgical resident who enters upon his training with the idea, which many residents unfortunately have, that his primary business is to operate must be disabused of it. He will spend much of his time in the operating room, it is true, and the basis of the residency system is progressive delegation of responsibility,

including the responsibility of operating, but permission to operate is a late privilege, not an early one. The resident must be closely supervised for many weary hours (they are often much wearier for his preceptor) before he is permitted to stand alone in the operating room. There is nothing worse for a young surgeon than too much freedom when he is just beginning to learn his specialty.

Not much is said about operating in the outlines of the objectives of a surgical residency as they are stated in previous editions of this text. That is as it should be. The surgical resident is in the hospital, as these earlier texts state, for a variety of other reasons: to learn and to participate in the care of patients with surgical diseases; to learn at first hand diagnosis and surgical pathology, as well as surgical methods and techniques of dealing with disease; to learn how to get along with sick people; to learn the limitations as well as the uses of clinical and biologic tests and instruments of precision; to develop a sense of relative values by combining the data secured from such tests with what has been learned from the patient's history and physical examination; and to learn good judgment in all sorts of surgical situations, whether they be elective or emergency. The resident will be taught these things by men who, by training and experience and with the passage of years, have come into a position to transmit their training and knowledge and experience to others. If he is wise, he will learn by their errors as well as by their successes. As Sydenham said, "There is a knowledge which cannot be written down, but can only be passed down by example."

There are a number of things about surgery that the resident must learn before he begins to operate. One important thing is that, as the late Lord Moynihan[2] put it,

> Surgery is not only a question of operating . . . The operation itself is but one incident, no doubt the most dramatic, yet still only one in the long series of events which must stretch between illness and recovery.

Moynihan wrote those sentences more than a quarter of a century ago. Elman's[3] fine book on surgical care, published in 1951, stresses the same point in its title, its preface, its dedication to the resident house officers and nurses "upon whose devotion to the patient the best of surgical care inevitably depends," and its total subject matter. Surgical care, Elman pointed out in his preface, is a goal, not the achievement of any special period. The recent improvement in surgical mortality and morbidity rates, of which we are all happily aware, can be attributed far more to the kind of care the patient now receives outside the operating room than to any radical alteration in the care he receives in it. Surgical residents who conceive of surgery only in the light of operation could turn their attention to Elman's book with a good deal of profit.

They could also profitably reflect upon other wise things that Lord Moynihan[2, 4] had to say about the science and art of surgery:

> . . . Surgery is not learned easily. The training is arduous and protracted; indeed, it lasts a man's lifetime. It must begin under a master's eye and be influenced by his criticism, and not less by his spiritual encouragement. It must not be lightheartedly or recklessly undertaken, nor can it ever be a matter of display. In recent years and especially . . since the war [it is World War I to which he is referring] the incompetent and ill-trained operator is allowed too free a hand and enjoys too wide a scope.
>
> . . . In surgical work, craftsmanship is much and knowledge is much and wisdom, which is the timely and rightful application of knowledge, is more, but as we establish our place in the world it is chiefly character that counts. . . .
>
> In surgery the hand of the beginner is heavy. This [he is speaking of advances in surgical technique] has unhappily led to the too frequent performance of operations, and to their performance by those whose judgment has not kept pace with their technical accomplishments.

The surgical resident today is not often an "ill-trained operator," for the very existence of the resident system makes for technical competence. When he enters upon his residency, however, he is no operator at all, and even after he completes it, although he may be *technically trained, he is certainly not* experienced, and he must not let the excellence of his technical training blind him to what he lacks in other respects

In a sense, it reflects a certain defect in

our medical teaching that it should be necessary to emphasize to young surgical residents that the act of operation is not their first goal. There is no known way, Orr[5] remarked, to make a man practice within his limitations. That is true. Furthermore, as has been repeatedly pointed out, anybody legally licensed to practice medicine can also legally operate on anybody ignorant enough or foolish enough to let him do it. There would be less of that sort of surgery, less need to curb the operative yearnings of interns and residents, if there were more stress in our medical schools, from the very day that students begin their studies, upon the ethics of surgery and upon the actual immorality of the performance of operations by physicians not trained for the task. C. Jeff Miller,[6] in his inaugural address before the American College of Surgeons in 1930, summed it up when he said:

> . . . We take the issues of human life into our keeping when we lay hands upon the human body, and only too often we take them with a carelessness and a lighthearted indifference that is wholly unbecoming and unworthy.

If the student has not been taught these principles in his undergraduate years, and has not learned them in his intern year, then the first duty of his preceptors in his residency must be to teach them to him, for his whole surgical training must be built upon them.

### SURGICAL RESIDENCIES

One reason why the surgical resident should enter upon his training with a serious sense of responsibility is that he represents the fruit of selection. As a medical student he was selected from many men who tried to enter medical school when he did. Some of them, perhaps, were just as good as he was, but for one reason or another they were less fortunate. He was selected for internship and still further selected for residency. The process of selection will continue as he climbs to the summit of the pyramidal structure that in most hospitals makes up the progressively higher grades of the surgical residency.

The process of selection still holds in principle even today, when there are available far more internships and far more of the lower grades, at least, of residencies than there are candidates to occupy them. It will be most unfortunate if these circumstances, which are probably transient, inculcate in interns and residents any feeling of complacency or any idea that their obligations are lessened because bids have been made for their services.

Another reason the surgical resident must use to the fullest the opportunities for training that are offered to him is that the clinical material for this purpose is decreasing year by year, and is also becoming more unbalanced. Several years ago Pearse[7] pointed out that at the Strong Memorial Hospital, ward patients, who make up the bulk of all teaching material, particularly the teaching material upon which residents may actually practice surgery, had declined from 68 per cent of the hospital population in 1934 to 17 per cent in 1945. The chief cause of the decline in this particular hospital was, paradoxically, the increase in hospital insurance, which 75 per cent of the community population held in some form or other. The effect of health insurance programs on the residency training in surgery is now even more serious, as the report of Bricker and associates[8] makes clear. Other causes which are producing similar effects are also paradoxical; they include the higher general level of prosperity, which has converted many formerly indigent persons from public charges to private patients, and removal of many persons from civilian hospitals to Veterans Administration and other government hospitals. Whatever the explanation, it is an admitted fact that except in the large public hospitals, which continue to have large populations available for teaching, the number of patients upon whom the resident may operate and thereby may acquire clinical judgment, technical skill, and self-confidence, is far smaller than it used to be.

Griswold,[9] in another realistic survey, called attention to the fact that in many

institutions clinical material is no longer well balanced. For teaching purposes the hospital population should represent a cross-section of the general population in respect to age, sex, inpatient and outpatient distribution, acute and chronic disease, and major and minor surgery. Many teaching hospitals, Griswold pointed out, can now supply only major elective cases, and many of the patients, if not most of them, reach these institutions only after the diagnostic problems have been solved. Research investigations, desirable as they are, sometimes lead to a disproportionate representation of uncommon diseases and a corresponding deficit of more frequent diseases. The reputation of certain staff surgeons for certain difficult and unusual operations may fill the wards with candidates for those operations, to the exclusion of other patients. Traumatic and emergency surgery, which makes up a large part of general surgical practice, has been greatly reduced in many hospitals and is not handled at all in others Finally, the hospital population all over the country is beginning to show a greater proportion of older persons, who are more likely to present chronic, nonsurgical diseases than the acute surgical conditions seen in a younger population.

In the light of these various facts, it behooves the surgical resident to make the best use he can of the didactic and practical opportunities at his disposal. He has been chosen by successive selection from many others, and the material upon which he must be taught must be distributed far more carefully than when it was more abundant.

#### CERTIFYING BOARDS

No better thing ever happened in clinical medicine than establishment of the various certifying boards and setting up of their criteria for specialization. It is no longer possible, as Hertzler[10] remarked, for a man to wake up some fine morning and declare himself a specialist.

It is inevitable, however, that with the benefits that have followed certification by the specialty boards there should come doubts and questionings. In the minds of some residents all the emphasis is upon certification, and the requirements that lead to it are fulfilled as casually and as perfunctorily as possible. Residents who do their work in this fashion should not be recommended for examination; there is more to surgical training than spending a specific number of years in a hospital. At the other extreme, many believe that the period of training for certification has become too long and too arduous, and that it is not desirable that the surgeon should be 30 years of age or even older before he is qualified.

Still others believe that too much attention is being devoted to specialization as such, and that the surgeon would be a better specialist if he had more general knowledge. It has even been proposed that the candidate for specialty training should be required first to pass an examination upon general subjects, on the ground that, as Sir Robert Jones[11] said, "Nothing is more fatal to progress than when, from defect of general surgical training, a specialist is limited to one view of a subject." Be this as it may, there is no gainsaying the extraordinary record of competence and efficiency chalked up by the general surgeons who in World War II took over neurosurgical responsibilities after only brief training in that field. The men who were responsible for the military program strongly believe that what was done in the stress of wartime needs can be done equally well, if not better, in the circumstances of peace.

The surgical resident who is preparing himself for board examinations must also guard against the pitfall of looking upon certification as an end in itself, a goal which, when reached, ends the need for further training. Responsible authorities are themselves becoming aware of the dangers of this point of view. It has been suggested, with a good deal of logic, that the time is coming when the boards, in addition to examining and certifying candidates, must make periodic checks of their products, to be certain that their diplomates are staying within their spe-

cial fields, especially in the large cities and teaching centers, where there is no reason at all for their straying beyond them; that they are not performing unnecessary operations, which is one of the most damning of the indictments now being brought against the profession; and that their mortality rates and morbidity rates are within reason for the type of surgery they are doing.

#### THE RESIDENT'S APPROACH TO HIS WORK

From what has already been said, it is clear that the attitude of the surgical resident and the spirit in which he approaches his training will determine what he derives from it. The old-fashioned virtues are still important, even in this somewhat cynical modern age.

The resident must obey the hospital rules, whether or not he agrees with them all, and he must be completely loyal to the institution in which he is working. The language that Stephen Paget[12] used is perhaps of another day, but his concepts are still worth pondering:

> What ought the student bring to the service of his hospital? He ought to bring those gifts which come of a good disposition, a good home, and a good public school. He should have reverence, and a fair liking for work, and a certain simplicity or directness of thought; and should know Latin and a manageable quantity of general facts, and should be resolute in company, and even against company, to say the right thing and take the right side.

Until the resident becomes a staff surgeon himself, he stands in the place of the attending physician to the patients. He must be completely loyal to him, being careful never to utter a hint of criticism of him to the patient or to the patient's family. This does not mean that he must not raise questions, or, on sound grounds, differ with him. A clinical teacher, Ogilvie[13] said, should surround himself with "why-men," and it is the exceptional senior surgeon who does not listen willingly and even gladly to what a younger man has to say and who does not accept his suggestions if they are grounded in careful observation. The proper place to raise questions and make suggestions is not, however, at the patient's bedside.

The resident must also learn to be patient with men who are frequently impatient and unreasonable because they are working at high speed and carrying heavy responsibilities, including the responsibility of training him and his associates. He will soon find himself in the same position, and will be hoping then that a new generation of surgical residents will be patient with him.

The surgical resident must maintain an attitude of courtesy and respect to nurses and other attendants. Personal relationships may properly exist, but the hospital wards are not the place for their exhibition. A certain amount of deference is not unbecoming to a young man. He is far from knowing all that he should know, and an experienced nurse can often teach a great deal to an inexperienced young resident. He would be well advised to learn from her.

The resident must expect to work hard. Even if he plans his work efficiently, as most residents do not, he will still find that he has more to do than time to do it in. Then he must learn what can most profitably be neglected. A resident who finds himself with time on his hands would do well to stop and take stock of himself and his activities. Something is wrong somewhere, and it is most probably with him.

It is highly unlikely that surgery will ever go on the 40-hour week. It is a full-time vocation. The surgeon, whether he works inside the hospital as a resident or outside as a private practitioner, will always find himself engaged in a ceaseless round in which petty duties often overshadow major tasks. Much of his work will be simple drudgery. His scheduled free time and his nights out will be broken into again and again, and there will be no compensatory time off. On the other hand, if he does not have a capacity for industry and a will to drudgery, he had no business entering the medical profession and he certainly has no business training for surgery. More than two thousand years ago Hippocrates listed "a love of labor" as one

of the qualifications of "whoever is to acquire a competent knowledge of medicine." The necessity still holds.

In the first edition of this book, Christopher thought it proper to advise the surgical intern to have regard for his manners and appearance. In these days of informal behavior and more informal dressing, when there is, unfortunately, universal laxity in the observance and enforcement of rules, the advice is even more necessary. Sport clothes and play suits do not belong in a hospital. Even after he has spent a long day in the operating room, or has been up most of the night, the resident should see to it that he is properly dressed, that his uniform is clean, that it is worn over the proper complement of shirt and tie, that his shoes are polished, that he is cleanly shaved, and that his nails are well cared for. The latter, incidentally, is also an essential operating room requirement.

### PHASES OF TRAINING

*The Outpatient Clinic.* The outpatient clinic, though it is an essential phase of hospital training, is often approached by the resident merely as another chore. The records reflect his feeling. Yet if he approaches the clinic tasks with interest and enthusiasm, and if he does his work conscientiously, he will be providing himself with an excellent grounding in general office practice, for the material that comes into the clinic is precisely the kind that comes into the private office. Here he will see patients with nothing at all the matter with them, patients with minor surgical conditions, and patients who are seriously ill and who often, in addition, present major diagnostic problems that may not be immediately evident. The resident should sedulously guard against developing the "return-in-two-weeks" mentality, which so often characterizes clinic management. Under it, patients who have nothing the matter with them continue to visit the clinic unnecessarily because the staff lacks the initiative to discharge them, while diagnosis may be delayed in patients with serious disease who may even lose their lives because, for trivial reasons and lack of earnest effort, their work-up was not expedited.

The specialty clinics, such as the vascular, thoracic disease and tumor clinics, which are operated by most modern general hospitals, obviously provide a wealth of valuable and highly specialized experience, of which the fullest advantage should be taken.

*Ward Rounds.* Ward rounds furnish one of the most instructive phases of the resident's training. Study of individual cases, their free discussion and linkage of related cases illuminate what is learned from textbooks and didactic teaching. "Clinical wisdom," as "Ogilvie[13] has well put it, "in its essence is case memory."

One warning is necessary in connection with ward rounds. There must be the greatest care about what is said in front of the patient. It is hard to say whether more harm is done by careless statements concerning his actual condition, or by remarks that he may misinterpret or may not understand at all. The only safe plan is to limit the discussion at the bedside to the facts of the history and physical examination and to complete it out of the patient's hearing. The same precautions hold for diagnostic and other clinics and for the operating room.

*Operating Room Service.* In the operating room the role of the first-year surgical resident is first of all that of an assistant. The visiting man appreciates, and later remembers, such courtesies as finding his resident there not only on time but ahead of time, to see that the patient is ready for operation and that his favorite instruments and the correct sutures have been laid out. If the resident has to wait for the visiting man, he can read, or he can practice tying knots with his fingers or with instruments. It is surprising what dexterity can be achieved by a little practice in odd moments.

It is usually the resident's responsibility to prepare the operative field. He should do it thoroughly, gently and carefully. Most preparations used for this purpose today are innocuous, but it was not so many years ago that an iodine

burn caused by careless skin preparation could cause a patient more discomfort than an abdominal incision.

At the operating table the resident must watch what he is doing and do what he is told, conforming to the desires and techniques of the visiting surgeon and making no moves on his own initiative. His own turn will come. One special warning is necessary, that all his manipulations should be extremely gentle. There is more appreciation today than ever before of the damage that can be wrought by trauma, and the resident, even while he is a remote assistant, can learn how to sponge rather than wipe and how to perform other manipulations so that there will be no trauma to the tissues that can possibly be avoided.

In this connection, it is now recognized that many of the infections that occur in burns and trauma are not primary. Instead, they arise from secondary contamination, introduced by carelessness and laxity in wound management, including the lax enforcement of sterile precautions. A striking error is failure to dress the wound by an aseptic technique, in which use of masks is obligatory.

*Attendance at Necropsies.* Christopher, in an earlier edition of this text, said forthrightly, "Any intern who does not actively try to be present at all autopsies is under some suspicion as to his real interest and devotion to the study of medicine." Certainly the surgical resident should consider it to be one of his prime responsibilities to attend every postmortem examination conducted while he is not engaged in other duties that cannot be postponed. Few medical exercises are more instructive or more conducive to avoidance of future errors and accuracy of future diagnosis and treatment. There are also few occasions that may furnish more striking surprises and that may deal greater blows to one's complacency than to see a diagnosis made on the basis of an apparently classic clinical picture turn out, indisputably, to be something entirely different. Many years ago Lord Moynihan[2] pointed out the lessening in the number of functional diseases brought about by demonstration at postmortem that they were actually dependent upon changes in structure. His warning should be remembered now, when emphasis upon the possibilities of psychosomatic medicine has real elements of danger.

The resident also has a personal responsibility in respect to necropsies. The number obtained is generally accepted as the best single index of the professional efficiency of a hospital and its staff. It often rests with the resident, particularly in a public hospital, to make the request for postmortem examination. If he makes it perfunctorily, carelessly, or callously and unsympathetically, if he accepts "No" for an answer as soon as it is given, the number he secures will be small. Recommended reading in this connection is Hoffman's[14] article dealing with methods of obtaining permission: It was possible, by a concerted effort, to raise the number of postmortem examinations at Memorial Hospital from 27 in 58 deaths in one 6-month period to 56 in 68 deaths in the next 6-month period. Hoffman's conclusion is well worth reflecting upon, that the most cogent reason for the numerical improvement in the second period was the gratitude of the patients' families for the kindness and consideration with which they, as well as the patients, had been treated.

*Research.* Some surgical residents may begin their training sufficiently interested in research to know already where their future interests lie. In others an interest may develop in this field as their training progresses.

Be this as it may, the resident who plans to devote himself to research must bear in mind that research activities are not necessarily carried out in the laboratory and do not always involve animal experimentation. Clinical research is an honored field, which is just as widely open to the entering surgical resident as to the experienced surgeon. All that is required is that he keep his eyes and ears open and that he record his observations accurately and honestly. It was by doing just that that James Mackenzie, for instance, with little training and few labo-

ratory facilities, at least as we envisage them today, rose from obscure beginnings to become a world authority on diseases of the heart. It was by doing just that that Sir William Osler became the world's outstanding clinician.

Once it would not have been necessary to warn the research surgeon that however deep his interest in research may be, the patient must always come first and the proposed remedy must do no harm. Now it is necessary. Now we have before us the horrible example of the degradation of the profession in Nazi Germany because its members forgot, or chose to forget, those principles. Ivy's[15] fine presentation of what happened in that country under Hitler should be required reading for all research students. His experience as an investigator at the Nurnberg medical trials made him realize, he says, the great practical and humanitarian importance of medical ethics. It also caused him to realize that his own medical education had been deficient in this respect and that medical educators today are negligent in teaching the young physician "the relation of the ethics of medicine to the economics of medicine."

Other investigators have emphasized these same dangers. Bean[16] pointed out that "the descent into the gas chamber by doctors of infamy" had its beginning in disregard for the patient, which research does not require. He reminded us, too, that as Claude Bernard said, performing experiments and operations exclusively from the point of view of the patient's advantage does not prevent them from turning out profitably for science.

#### PRACTICAL CONSIDERATIONS

***History-taking.*** Many eminent physicians have said that if they had to choose among the various data by which a diagnosis could be made and treatment outlined in any given case, their choice would be the patient's history. Osler said that he could make a diagnosis from a medical student's physical examination if he were permitted to write the history. It is regrettable, therefore, and perhaps a reflection upon the teaching they have received in their medical courses, that surgical residents so often feel that history-taking is for students and interns and is no part of their responsibility. If hospital rules make supervision of histories part of their duties, they regard the task as something to be got out of the way as rapidly as possible. Their attitude is reflected in the results. All too often, as Walshe[17] said in his 1950 Linacre Lecture, histories are "flat and incoherent chronicles, thickly sown with irrelevances."

It has been suggested that the patients' records in any institution would take an instant turn for the better if every intern and resident, before he entered upon his duties, were required to prepare a paper based upon analysis of a minimum of one hundred hospital records. The proposal has merit. Review of histories is a reasonable and useful basis for preparation of medical papers. The literature has been enriched by such studies. Yet the analysis is frequently an ordeal out of all proportion to the information gleaned because the records are often little more than a phlethora of words, disorganized, unnecessarily repetitious, badly and illegibly written, and deficient in many other essential respects. The irony is that it would be just as easy, and sometimes easier, to make them good records.

One urgent reason for seeing to it that records are correct and complete is that one never knows when the record may become legal evidence. The possibility lurks in every accident case. It is the background of every burn from a hot water bottle, every fall from a bed or a roller, or any similar accident Suits for malpractice arise in the most unexpected cases. Usually there is no ground at all for the accusation, but the resident should be certain, for his own protection and the protection of the hospital, that his records will stand up to legal scrutiny.

Each hospital has its own forms and formulas for history-taking. Some are perhaps better than others, but the value of them all depends, in the long run, upon the interest and care with which

residents and interns carry out their parts of the task.

Certain special points need comment:

1. There will be far better cooperation from the patient, no matter what his social or educational level may be, if it is explained to him, or to the person from whom the history is to be secured, why it is being recorded and what kind of information is desired.

2. The history should begin with a brief statement concerning the source of the data and the apparent reliability of the informant. Thereafter "The patient says" should not appear in the record. This simple omission will save a surprising amount of time, space and effort.

3. The patient should be permitted to tell the story of what is the matter with him in his own words, without questions, which are frequently leading even when they are not meant to be. Afterward he may be questioned on special points as necessary. The historian should not attempt to write the history at this time, and should make only brief notes. Later he should go back and write the connected story.

Admittedly, it takes a great deal of patience to listen to some case histories. Frequently they tend to be rambling and garrulous. But this is a method by which, in the end, time lost is time saved. It has a number of advantages. In the first place, it permits the historian to find out a good deal about the patient himself as well as about his symptoms. In the second place, it permits the presentation of the history in chronologic form. Too many stories do not begin, as they should, with what Moynihan called the earliest departure from health that the patient can recollect. Instead, they begin with what happened yesterday or this morning to make him come to the hospital. Nothing is more exasperating than to try to trace a history forward when it has been written backward.

Finally, the writing of a history by the method just recommended permits proper assessment of symptoms, and indicates the order in which they should be investigated. The cold from which the patient has just recovered or is still suffering may fill his thoughts to the exclusion of his unexplained loss of weight, or his recent change in bowel habit, or the breathlessness which he has begun to experience whenever he walks upstairs. Anyone who has read history after history in which the important data are buried under masses of irrelevant details will need no further exposition of the value of a more logical method of presentation. As Ogilvie[13] put it, after the facts are marshalled, assessed and allotted to their relative stations, the place of the "most clamant" is not necessarily the leading place.

4. The history should be precise. "Last Monday afternoon" may be illuminating to the physician who reads the history Tuesday morning. It is useless a year, or even a month, from "last Monday" to the reader who is trying to find the elapsed time between the onset of symptoms and medical consultation in a series of cases of acute appendicitis or acute intestinal obstruction. It should be an infallible rule of history-taking to record the precise date and hour, followed by A.M. or P.M., in the recording of any acute condition, and to be as precise as possible in the chronology of nonacute conditions. Often, even if the disease has not had a really acute onset, the patient can tell almost to the hour, as well as to the day, when his illness began. If, under careful questioning, he cannot furnish even an approximate date, that also may be a point of diagnostic importance.

The same precision should be used throughout the history and physical examination. Vague statements are frequently meaningless. It requires little more effort, and adds immeasurably to the value of the record, to be specific about such things as the location of a pain in reference to regional anatomic landmarks and its possible relationship to food and fluid intake, and to bowel, bladder and menstrual function; the character of vomitus; changes in bowel function; the length of a scar; and the location, size, consistency and mobility of masses anywhere in the body.

5. Tiresome as it may be to go through all the systems in every case, it simply

does not pay to omit a complete review. The patient, even though invited to state all his positive complaints when he is relating his present illness, often omits some detail because, since the symptom or sign does not annoy him, he considers it unimportant. Sometimes it is the clue to the whole mystery or is the index to a totally unsuspected disease. A sudden aversion to meat, for instance, may be the first indication of carcinoma of the stomach. The need for less bed covering in cold weather may indicate thyroid disease. So may the need for a larger collar. These "inaugural symptoms," as Moynihan[18] called them, are always important and their prompt recognition is sometimes lifesaving, but they are often so slight that the patient, unless particularly questioned, may overlook them altogether.

***Physical Examination.*** Not much need be said about the physical examination except that, like the history, it should be from head to toe. The resident should train himself to look as well as to feel, and, as already pointed out, to record his findings with absolute accuracy.

It would seem scarcely necessary to issue the warning, except that one so often hears of reckless carelessness in this regard, that a male physician should not examine a female patient or carry out any sort of treatment on her unless a female attendant is present. This rule must be scrupulously observed with patients who are emotionally unstable or who are neurotic or psychotic. The resident who finds himself in trouble from failure to observe it has only himself to blame. Even though he is innocent, his position is always unpleasant. Not all physicians know that an accusation of rape is a capital charge and that, once it is made, control of the situation passes out of the hands of the hospital authorities, who themselves become lawbreakers if they do not instantly report it to the constituted legal authorities and let matters take their prescribed course.

***Laboratory Tests.*** Within limits, the ordering of laboratory work is likely to be left to the resident. Today he has little or none to perform personally, but if he does, he must be honest, careful and accurate. The "sink test" was never really funny.

Urinalysis and hematology, sometimes with the addition of blood serology, are routinely performed on all patients. Blood typing is never omitted before any major surgical procedure, and is frequently routine in all admissions. Beyond these tests, fine discrimination is necessary in the invocation of the laboratory for diagnostic aid. As Starry[19] said, we are now in an "age of laboratory debauch," and it is possible to judge a man's clinical ability by observing whether, when he picks up a patient's record, he reads the history or turns first to the laboratory reports.

There would be no particular profit in trying to estimate how many of the laboratory tests performed today are unnecessary. It is enough to say that a great many of them are open to the charge. Blood chemistry determinations and complicated liver function tests are repeated time after time when there is no indication at all for the repetition or, sometimes, for their initial performance. A barium enema is ordered in suspected carcinoma of the rectum, in which digital examination, followed by proctoscopy and biopsy, is diagnostic while a barium enema is usually useless. Gallbladder visualizations and basal metabolic rate determinations are made in patients with no suspicion of biliary tract or thyroid disease. Repeated cytologic examinations are made in patients with suspected carcinoma of the lung or the stomach when their best interests would be served by prompt surgical exploration.

This sort of practice adds enormously to the cost of medical care for both patient and hospital. It occupies uselessly the time of laboratory physicians and technicians. It frequently delays surgery which may be urgent, even if not a true emergency. It slows down the turnover of hospital beds and the business of the clinics. Finally, it has a bad effect upon the resident himself, who develops the habit of relying upon the laboratory when he should be developing his own clinical ability by use of the senses that

God gave him and recollection of his own past experiences. He will find, when he goes into practice, that these futile luxuries must end, for the average private patient simply cannot afford them. The same rule should hold for public and government hospitals, in which unnecessary laboratory work is frequently done because there is no limitation on what is permitted.

Several other points should be made in connection with laboratory testing. One is that if it is really necessary, the resident should write the proper orders for the tests and see to it that they are carried out. Neither proctoscopy nor a barium enema, for instance, is of any value unless the lower bowel is properly cleaned out. Renal function tests are invalidated if food or fluid is taken while they are in progress. The proper attitude on the part of the resident, and a few minutes to explain the rationale of the test and the circumstances under which it must be performed to nurses and patients, will save the time and expense of repeating the work.

Attention should also be called to the necessity for discretion in ordering such procedures as bronchoscopy and esophagoscopy. Patients with diseases in which they are of diagnostic value often do not require them for diagnosis and may be so debilitated that they cannot tolerate the strain that these measures impose. More than one sudden death has been reported after their unwise use.

Whatever tests are carried out, the reports on them should be studied and evaluated. The suspicion may be unworthy, but it often seems that tests that are requested thoughtlessly are merely attached to the record when they are reported. In particular, it will always pay the resident to look at the report of tissues returned from the laboratory, and to look at it while the patient is still in the hospital; it is not always easy to induce him to return for further treatment or for observation. A frozen section reported benign in the operating room sometimes proves malignant on further examination. An innocent-looking appendix is sometimes the site of a carcinoid tumor. A bit of tissue snipped from the mesentery in the course of an uncomplicated appendectomy on a young girl may be an implant from a papillary cystadenocarcinoma; with peritoneal seeding her chances are poor, but they will be improved by immediate radical surgery followed by deep roentgen ray therapy. Failure to examine the laboratory record, and to examine it promptly, has deprived many a patient of the chance for life.

*Progress Notes.* The only excuse for not writing progress notes on the chart is a patient's uncomplicated progress. Unfortunately, in most hospitals the absence of progress notes cannot be so construed. It is therefore recommended that for at least 72 hours after operation the resident write a specific note to the effect that progress is smooth, and that he write a final summary of the postoperative course, including the date of removal of the sutures.

Progress notes, in themselves, are useless unless the story of what is happening to the patient can be derived from them. Often it cannot be. One should not be driven to try to find out from a nurse's chart what a temperature elevation means, when drains were removed, whether blood that was ordered was given (the mere order does not warrant that inference), and whether administration of heparin means that a patient had a positive Homans' sign, actual phlebothrombosis or a full-blown embolism. In short, progress notes should state clearly the symptoms and physical signs which are present, the actual or suspected complications, the treatment ordered and what happened next.

As a general rule, it is well to refrain from stating on progress notes what is to be done. All too often the record ends with a mere statement of intention. Nothing is more futile than to read, "Will do blood chemistry tomorrow," or "Will transfuse Thursday," or "Will give Amigen Monday," and find nothing on the chart to indicate whether or not the intention was translated into action.

*Summary of Record.* Every history and physical examination should conclude

with a brief summary containing the salient points of the story and findings and the tentative diagnosis. When the patient leaves the hospital, there should be added to this summary a statement concerning positive laboratory data, the treatment employed, the important points of the preoperative and postoperative course, and the final diagnosis. The resident will find it a useful experience to prepare such summaries. As Strachey said, the best test of a man's intellectual capacity is his ability to make a summary.

Clinical summaries are also a great convenience for anyone who must use the histories later. It is curious, as one examines hospital records, how the heart leaps up when one recognizes certain handwritings and realizes that here, at least, are records which are reliably summarized and in which it will not be necessary to wade through many pages of barren and illegible detail in order to secure the facts.

***Handwriting.*** It is not too much to ask, and it is unfortunate that hospitals do not insist, that interns and residents, if they cannot write legibly, should learn to print clearly. This holds for the history, physical findings, progress notes, orders and anything else in writing that may be attached to the record. Anyone who endeavors to study series of cases encounters records that are utterly useless because they cannot be read at all or require an inordinate amount of time to decipher, even in part. There is simply no excuse for the hieroglyphics which nurses are forced to interpret, and it is remarkable that serious, and even fatal, errors are not made because they are obliged to do so.

***Response to Calls.*** The resident will save himself a great deal of trouble, particularly at night, if he makes regular rounds, as late as possible, and if he writes comprehensive orders. Whether he does or does not do this, however, he must form the habit of answering calls promptly and of answering many of them in person. He must avoid the habit of telephone diagnosis and prescription He must beware of the assumption that any call at all is trivial, regardless of the source from which it emanates.

Often he will find, when he answers a call that seems to be an emergency, that it is not even urgent. Often he will find there is no real physical basis for a patient's complaints. He must not, however, let himself slip into the habit of assuming that, because this is so, he has no responsibility in the matter. He has a great deal. The care of patients is not all physical. Many authorities believe, with justification, that the pendulum today has swung too far in the other direction. There is, nonetheless, mental as well as physical suffering in many surgical illnesses, and the resident will find, when he enters practice himself, that much of whatever success he may achieve will depend upon his ability to manage his patients by kindness and understanding. He cannot begin too early to practice these virtues.

***Preoperative and Postoperative Care.*** The preoperative and postoperative routine is well standardized today and is usually well carried out. Orders must be in accord with the desires of the attending surgeon until the resident is put upon his own responsibility. They should be written promptly, completely, accurately, legibly and in ink. They should always be signed. It is most important that orders be written promptly, for few hospitals permit nurses to accept verbal orders and none permit them to proceed on their own responsibility.

A few general principles of preoperative and postoperative care might be emphasized:

1. Narcotics should be used sparingly. The average patient can get along with smaller amounts than are usually ordered, and will be the better for it. Also, narcotics can frequently be withdrawn earlier than they are.

2. Fluids should be used with discretion, particularly in elderly patients, in those with cardiovascular and cardiorenal disease, and in those with impending or actual lower nephron nephrosis Solutions containing salt should be given

only when they are indicated. The possibility of potassium deficits should be borne in mind.

3. Similarly, blood should be used only as necessary. Unnecessary amounts do no good, put an unwarranted strain upon the circulatory system, and foolishly waste an adjunct substance that is harder than any other to procure. Anyone who doubts that blood is wasted unless it is administered scientifically and upon indication should read the illuminating study by Parsons and his associates[20] on blood volume determinations in surgery.

4. Vitamins should be used only on indication. The average patient who undergoes elective surgery, who has been nourished by mouth up to the time of operation and who will be returned to oral feeding in a matter of days or even hours, has no real need for any such dietary supplement.

5. Antibiotics should be used in moderation and only upon indications. The present indiscriminate use of these agents is rapidly becoming a major medical problem. This practice adds enormously to the cost of medical care. It encourages growth of resistant organisms. It can do other harm, as is shown by the numerous reports on fatal aplastic anemia resulting from chloramphenicol therapy. Unnecessarily massive dosages are often used. Finally, the combinations in which these agents are used are often illogical and frequently cancel out the effects of the individual components.

Discretion and moderation in these and similar details will reduce the cost of medical care, a matter with which all physicians must be seriously concerned, and will not in any way jeopardize the patient's recovery. It is probably easier for the resident to write routine preoperative and postoperative orders than to individualize them for each patient, but it is another habit that he should guard against.

*Postoperative Observation.* Most patients today recover smoothly, even after serious surgery, but that is no reason for assuming that all will. Careful observation is still necessary to detect incipient complications. It is more necessary than it ever was, in fact, because of the ability of antibiotics to mask them completely by suppressing the symptoms to which they give rise. Gastric dilatation, ileus, intestinal obstruction, postoperative hemorrhage and shock, and thrombosis and embolism may be less lethal today than they were a dozen years ago, but they still occur and they must be watched for. Vomiting may presage the onset of ileus and obstruction. A fall of a few points in the blood pressure may indicate that hemorrhage is occurring or that the patient is slipping into shock. A minor lack of balance between intake and output may herald the onset of anuria and lower nephron nephrosis. All the care in the world cannot prevent every embolus, but it still pays to examine the patient several times daily to try to pick up Homans' sign. The outcome of these and other complications may be so disastrous that any amount of effort—and routine, careful observation does not require any great effort—is worth expending to detect them in their incipiency.

The surgical resident must also bear in mind a fact that should be obvious but that is often forgotten, namely, that the existence of one disease does not guarantee that the patient does not have, or will not develop, another and perhaps even more serious disease. Carcinoma of the stomach or lung may go unrecognized while a patient is treated for a fracture or operated on for a uterine fibroid or a hypertrophied prostate. Patients with tuberculosis and cardiac disease have died of unrecognized ruptures of the appendix or gallbladder. Patients under observation for peptic ulcer have lost their lives because the ulcer perforated without recognition. Ironically, statistics suggest that the most unsafe place in the world for a patient to develop a disease which may be catastrophic is the hospital while he is under observation for another disease.

#### NOTE-TAKING AND NOTE-KEEPING

One of the first things a surgical resident should do (it would be better if he had done it earlier) is to decide upon

some form of note-keeping which is practical for daily use and at the same time lends itself to permanent filing. How this should be accomplished is an individual matter. There is no right or wrong way. Some people who keep notes successfully prefer a small, loose-leaf notebook. Others prefer small cards. Still others prefer small pads with detachable pages. Three-by-five cards and pads are convenient, but larger sizes may be used if desired. The only important considerations are that the means for note-taking always be at hand, in the resident's pocket and on his desk, and that the notes he makes either be destroyed when their usefulness is finished or filed if they are of permanent value.

Literally everything should be noted: the instructions of the visiting surgeon; the particular points that the resident wishes to call to the surgeon's attention about his various patients; the things the resident wants to remind himself to do for a patient or to note about him; the name, hospital number and diagnosis of a patient with an interesting or unusual disease; the reference to an article that is called to his attention, or that he runs across but has not time to read at the particular moment, or that he is recording as part of a collection of references he is building up on some special subject.

It is an easy matter, if this plan is followed, to build up a file of references on any particular subject. The following form, recorded on a 3- by 5-inch card, is recommended because the items are all inclusive:

> Jones, John Jr.
> A new method of anastomosis in resection of the colon
> Ann. Surg.
> 286:521–535
> August, 1962.

The resident will not find his notes useful unless three conditions are met: (1) They must be made so regularly in the beginning that it will not be long before the practice becomes almost automatic. (2) They must be brief, but at the same time sufficiently full to be lucid when they are referred to later; one's own notes will not be intelligible unless this precaution is observed. (3) They must be made so legibly that they can be read when the subject matter has been forgotten; even one's own handwriting may be illegible after passage of time.

The keeping of notes and references will probably seem an arduous chore when the practice is started, but it will soon become second nature, and in the course of months and years it will furnish rich rewards.

### READING AND DISCUSSION

Whatever may be said for the modern system of education, medical educators will testify that it has produced a race of students who, with few exceptions, no longer read as did their ancestors or their immediate predecessors. The average medical student has an unbounded respect for the printed word, a respect which he carries over into his internship and residency. If a statement appears in a book or journal, he is inclined to accept it with no questions asked, which is not a wise frame of mind. Yet it is what might be expected in persons who have had little training in the collection and classification of references, in the selective use of medical literature, in the evaluation of data, or in the reading of books for pleasure as well as for profit.

This is a singularly unfortunate state of affairs in a day when a succession of new discoveries and of changes in concepts and methods requires the physician not only to keep informed on the current literature but to read it understandingly, perceptively and discriminatingly. If the surgical resident does not already have the habit of using the library regularly and of reading a certain amount every day, it is a habit he should acquire forthwith. If he reads too slowly to cover the ground he has set for himself, then he must train himself to read more rapidly. It can be done.

As to what the resident should read: In the field of medical journals he should certainly read his local journal, even

though many local journals leave much to be desired. He should also read the *Journal of the American Medical Association; Surgery; Surgery, Gynecology and Obstetrics;* and the *Annals of Surgery* and the *Archives of Surgery*. It would pay him to read the *British Journal of Surgery*, and at least to glance over the *British Medical Journal* and the *Lancet*, for British journals are written with an ease and grace which most American medical writers do not possess. If his training runs to French and German, which, regrettably, it seldom does, he should include medical journals from those countries in his reading.

It would also profit the surgical resident to read many of the things which are now old-fashioned and of which perhaps he never heard, in particular Stephen Paget's *Confessio Medici;* Lord Moynihan's various books of surgical essays, which have been freely quoted from in this chapter; Cushing's *Life of Osler*, and Osler's own medical essays. They provide something which is for the most part lacking in present-day medical literature, aside from the fact that many of the clinical observations in them are still as valid as the day they were written. Ogilvie's *Surgery Orthodox and Heterodox* is a stimulating recent addition to the list.

In addition to forming the habit of reading widely, the surgical resident should train himself in the intelligent discussion of cases and issues during ward rounds, diagnostic clinics and clinicopathologic conferences. Often he will be called upon to present the clinical and laboratory material for these exercises, and he should see to it that the presentation is not, as it so frequently is, as painful an experience for his listeners as it is for the narrator. It is perfectly possible, if enough effort is made, to summarize the material succinctly and present it logically, in a series of orderly and related statements.

Much medical discussion today is, unfortunately, both superficial and commonplace. One reason is that the average physician, through lack of training, does not know how to present his own views, often because he has not thought them through adequately. Obscurity of language, said Lord Moynihan,[2] often means obscurity of thought; words may come after thought, but they do not follow far after.

Another and even more regrettable reason for the superficiality of many medical discussions is that the average physician, because he is supersensitive or for other reasons, is inclined to regard any difference of opinion as a reflection upon his methods and skill. As a result, what should be a stimulating exchange of ideas becomes little more than a studied attempt not to tread upon anybody's toes. For an example of how medical discussions can be conducted profitably the resident is advised to form the habit of reading the weekly case reports of the Massachusetts General Hospital in the *New England Journal of Medicine*. They are outstanding illustrations of presentation and development.

## CONCLUSION

In the end, of course, what the surgical resident desires from his training and what he secures from it depend entirely upon what goals he sets for himself and what he does to attain them. Most physicians are not likely to be guilty of what the British term "infamous conduct in a professional respect." Yet there are few, no matter how hard they have striven, who will not look back with regret upon this episode and that, this act of commission and that act of omission, this missed opportunity, that word which might better have been left unsaid. These are individual ghosts, which rise to plague us all. It is not cynicism, it is merely realism, to remind the young physician who is beginning his surgical residency that it is a law of life that chickens do eventually come home to roost and that he cannot expect the rewards of his profession unless he makes his own contributions to it.

There is no better way to end such a chapter as this than to cite a passage that has been quoted repeatedly in similar connections, Sir James Paget's[21] analysis of what happened to a thousand medical

students fifteen years after they left St. Bartholomew's, and the conclusions he drew from his analysis. Twenty-three of the thousand had achieved distinguished success, 66 considerable success, 507 fair success, and 124 very limited success. The remainder had left the profession, or had died in school or after beginning practice, or had failed altogether.

"In remembering those with whom I was year after year associated," Sir James wrote,

> and whom it was my habit to study, nothing appears more certain than that the personal character, the very nature, the will of each student had far greater force in determining his career than any helps or hindrances whatever. All my recollections would lead me to tell that every student may draw from his daily life a very likely forecast of his life in practice, for it will depend on himself a hundredfold more than on circumstances Time and the place, the work to be done, and its responsibilities, will change; but the man will be the same, except in so far as he may change himself

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*Part II*

# Skin and Subcutaneous (Adjacent) Tissues

# Chapter 7

# Anomalies

*By John M. Howard*

## PILONIDAL SINUS
### (Sacrococcygeal Sinus)

Pilonidal sinuses are congenital defects in the intergluteal fold. Often present and annoying to the patient, they present a therapeutic problem that has not been satisfactorily solved.

***Etiology and Pathology.*** The sinus, which is present at birth, is obviously a developmental defect. It has been attributed either to failure of closure of the caudal end of the neural canal[1] or to invagination of ectoderm in the sacrococcygeal area.[2]

The term "pilonidal" (Latin: *pilus*, hair; *nidus*, nest) indicates the high incidence of hair within the sinus. Grau[3] found hair in 72 per cent of 499 sinuses studied, a fact that would suggest an ectodermal origin.

The congenital defect is a sinus, rarely a true cyst. If a cyst forms, it usually results from secondary obstruction of the external opening. It is the obstruction of the sinus that appears to predispose to infection in the depth of the sinus tract. Because of the high incidence of acute inflammation of pilonidal cysts in soldiers riding in jeeps, this complication has been spoken of as the "jeep-rider's disease." The relation can best be explained by the trauma resulting from riding on a low seat with knees high, the weight of the body being thus shifted posteriorly to the sacrococcygeal area.[4] The high frequency of complications of pilonidal, thyroglossal and branchial anomalies in the young adult, however, suggests the possibility of an endocrine factor manifesting itself at this stage of life.

The diagnosis is simple and may be made by inspection. The lesion appears as a tiny opening in the skin in the intergluteal fold (Figs. 62 and 63), located in the midline and overlying the lower end of the sacrum or sacrococcygeal joint. *There may be one or several openings* to the skin, but prior to the onset of infection, all are in the midline. After puberty, hair may occasionally protrude from the sinus, but this is not a common finding prior to operation.

Pilonidal sinuses are seen three times as often in males as in females, and are rarely encountered in Negroes.[3]

The patient seeking treatment is characteristically a young adult, for it is at this stage that complications develop. It is just as unusual for a pilonidal sinus to produce symptoms in older people as in children. In the young adult the sinus may begin to produce a chronic discharge or, more frequently, an acute infection. A chronic discharge here, as in any other part of the body, may cause local maceration, pruritus and slight staining of the clothes, but it is seldom disturbing to the patient.

Acute infection of a pilonidal cyst, on the other hand, may result in severe pain. Indeed, few lesions are more painful. The acute inflammation is due to infection of the sinus tract beneath an obstructed cutaneous outlet. An exquisitely painful mass may be the first indication of the anomaly. Examination will seldom reveal evidence of inflammation commensurate with the severity of pain. The inexperienced physician may even doubt the presence of a purulent collection until the cyst is incised.

The original sinus is limited to the midline, but infection may burrow to either side, more frequently to the left. Spontaneous drainage usually occurs laterally but may occur through the orig-

inal cutaneous orifice. Thus, spontaneous or surgical drainage may produce an acquired sinus, opening away from the midline.

*Treatment.* Treatment of pilonidal defects consists first in incision and drainage of the pilonidal abscess and then excision of the pilonidal sinus.

*Pilonidal Abscess.* By the time an acutely inflamed pilonidal defect causes the patient to consult a physician, an abscess requiring incision and drainage has developed. Antibiotics and applications of heat are in themselves insufficient treatment, for subsidence or spontaneous drainage is a slow and painful process. Excision must be delayed until subsidence of edema and inflammation makes dissection in this area less difficult and until danger of spreading infection by lateral mobilization of tissue becomes less likely.

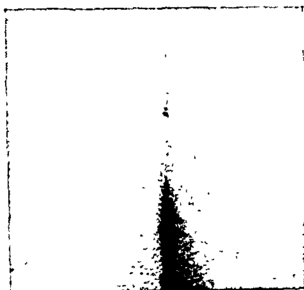


*Figure 62.* An uncomplicated pilonidal sinus

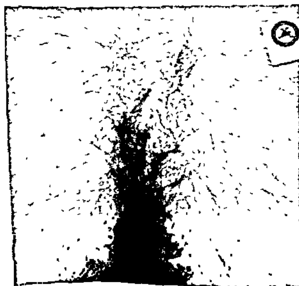


*Figure 63.* Two midline openings of a pilonidal sinus.

Incision and drainage can be performed under local anesthesia but pressure from injection of the anesthetic agent causes severe pain. Spinal or general anesthesia is, therefore, preferable. An incision is made over the abscess, and the pus often escapes under pressure. Relief of pain is dramatic. After the abscess cavity has been emptied and irrigated, the wound should be packed open with iodoform gauze. The patient should then apply heat locally or take several sitz baths daily. Administration of penicillin may be of value during the first three or four days after incision and drainage, although immediate complications are rare. The pack should be removed on the second or third day. The wound should again be irrigated and a smaller pack re-inserted. The edges of the wound must be kept apart until the abscess cavity fills with granulation tissue. Recurrence of infection is so common that the sinus tract should be excised about 8 weeks later, by which time the acute inflammation has usually completely subsided.

*Pilonidal Sinus.* Theoretically, the treatment of choice is complete excision of the pilonidal sinus and complete closure. This is sometimes difficult to achieve and attempts have resulted in many variations in surgical techniques as well as many operative complications. The difficulties in therapy are due primarily to imperfect tissue approximation after excision. Because of the high incidence of operative complications, some surgeons have abandoned elective operations for excision of these sinuses.

Rogers and Hall,[5] in a careful study of resected pilonidal sinuses, provided a basis for improved therapy. Their findings may be summarized as follows:

1. At the time of treatment, more than 70 per cent of the sinus tracts are simple midline structures which could be ex-

cised in a specimen of tissue 2 by 2 by 5 cm. Radical removal of tissue in this group is unnecessary.

2. Dyes injected into the sinus, in an effort to outline the sinus tract, stain normal lymphatic tissue and give the surgeon a false idea of the extent of the sinus.

3. The lateral extent of the sinus is not a congenital defect but is the result of perforation and extension by infection.

4. "Recurrence" is not usually due to a residual epithelial tract but to chronic infection in unobliterated dead space.

These principles indicate that excision is easier and conservation of tissue is possible if therapy is provided prior to the complication of infection.

Excision and closure of a pilonidal tract should be performed under spinal anesthesia with the patient hospitalized. The technique of excision of the small, uncomplicated sinus tract is simple, but excision of the scarred, previously infected sinus may be a major undertaking. The operation is best performed through a longitudinal elliptical incision around the sinus. The tract is followed cranially along the presacral fascia, and care is taken to excise the sinus in its entirety. *For promotion of primary healing, hemostasis must be complete, and dead space must be obliterated to prevent collection of serum and secondary infection.* It is necessary to undermine the lateral edges of the wound at the fascial level in order to obtain approximation of the tissues.

In chronically infected, scarred tissues, complete excision may make primary closure impossible. Under such circum-

Wenger,[6] in treating 90 patients, closed 65 wounds primarily and grafted 25. Ten of these patients (9 per cent) had secondary wound breakdown with persistence of a drainage tract. These "recurrences" *develop immediately and are* due to chronic infection and fibrosis in a deep, unobliterated wound space. In such patients, the period of disability may be several weeks.

Progress in the treatment of this defect *will* probably come as a result of earlier excision, during infancy. Koop,[7] in a series of 75 infants, found prophylactic excision of pilonidal sinuses during infancy technically easy with minimal complications. The surgical defect that resulted from excision at this time was so small that closure was technically easy. Even if infection results in wound disruption, healing led to complete closure within the following week. Recurrences have not yet been noted in this group.

## BRANCHIAL ANOMALIES
### (Cyst, Sinus and Fistula)

*Etiology.* The origin of branchial anomalies remains controversial. Embryologists agree that they are related to the branchial apparatus, but whether they arise from branchial clefts or the thymic duct is unknown.[8] On the theory that they originated from the branchial clefts, many authors have described anomalies of the first, second and third branchial clefts. Though widely used, this etiologic classification should be accepted with reservation. It is based on the assumption that these branchial clefts, originally pharyngeal diverticula, may fail to become obliterated, remaining as complete *fistulas from pharynx to skin; may close* at skin and pharynx to form branchial cysts; or may remain open only at the skin (branchial sinus) or at the pharynx (incomplete branchial fistula).

The highest anomaly in this group is a preauricular defect which is often considered one form of the anomaly arising from the first branchial cleft. It is characteristically a superficial sinus (Fig. 64) or, less frequently, a preauricular cyst. Byars and Anderson[9] described another anomaly which they attributed to a developmental defect of the first branchial cleft. This cyst or fistula lies parallel to the mandible and may drain into the external auditory canal (Fig. 65), leading to the erroneous diagnosis of external otitis. It should be recalled that the eustachian tube results from the normal development of the first branchial cleft, a fact which lends interest to their concept.

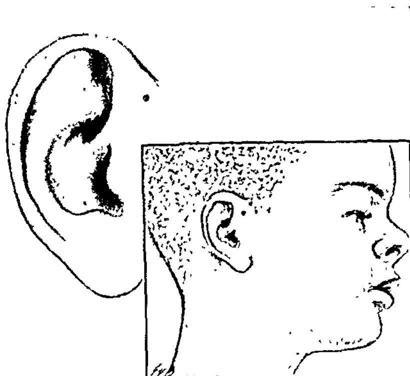


*Figure 61.* This preauricular sinus is the highest of the branchial anomalies. It is a superficial sinus originating from the first branchial cleft.

The commoner forms of branchial cyst, fistula or sinus (Figs. 66–70) are those of the neck, which are developmental defects of the thymic duct or of the second and third branchial clefts. They lie along the anterior border of and parallel to the sternocleidomastoid muscle (Fig. 71). If an internal opening exists, it is located at the tonsillar fossa. If an external opening remains, it lies along the anterior border of the sternocleidomastoid muscle above the clavicle (Fig. 72).

Histologically, these anomalies are lined with epithelium of the squamous, columnar or transitional types. Lymphoid follicles beneath the epithelial lining are numerous.



*Figure 65.* Indicating line of incision over the position of another branchial cyst or fistula which probably arises from the first branchial cleft (after Byars and Anderson).



*Figure 66.* A branchial cyst (and sinus) lying along the anterior border of the sternocleidomastoid muscle.



*Figure 67* Lateral view of branchial cleft cyst in lower part of neck near sternoclavicular articulation.

*Clinical Manifestations.* The branchial cyst occurs most frequently at the angle of the jaw but may be found at any level between the tonsillar fossa and the lower neck.[10] Although it is a congenital defect and may occasionally be detectable within the first week of life, it is more frequently discovered in young adults. Characteristically it appears as a painless, nontender mass (see Figs. 67, 68), but if infection develops, usually after an upper respiratory infection, it becomes a painful, inflammatory mass.

An internal opening at the tonsillar fossa is rare, but an intermittent discharge into the pharynx is highly suggestive of a branchial fistula.

A sinus opening may be present at birth along the anterior border of the lower sternocleidomastoid muscle. It may be entirely asymptomatic or may produce an intermittent discharge of epithelial secretion. The sinus, like the other defects, may be unilateral or bilateral. Incision and drainage of an infected branchial cyst may result in development of an acquired branchial sinus.

*Diagnosis.* The diagnosis of branchial cysts is based primarily on their location. A soft, nontender, elongated mass, 3 to 8 cm. in length, along the anterior border of the sternocleidomastoid muscle is almost pathognomonic. Although attached to the deeper structures, it is not adherent to the overlying skin except at a sinus opening. The sinus opening, if present, is also diagnostic.

The lateral location distinguishes the branchial cyst from the thyroglossal cyst. More difficult to differentiate is cervical lymphadenopathy, which is largely a distinction between chronic lymphadenitis and a chronically infected cyst. The distinction is based on absence of other large lymph nodes, mobility of the skin over the cyst, and the possible presence of a sinus on one or both sides of the neck.

*Cystic hygromas* are usually lower in the neck and are more diffuse. *Carotid body tumors* are harder than branchial cysts, occur much less frequently and are usually in older people. *Neurofibromas* are firm and may be multiple. *Metastatic carcinoma,* which occurs in older people,



*Figure 68.* Branchial cleft cyst which might be confused with a cystic hygroma.

can usually be distinguished by finding the primary tumor.

***Treatment.*** Curative treatment consists in complete excision, preferably with the patient hospitalized. The cyst should be excised when it is first noted in order to prevent the complication of infection. An asymptomatic sinus in a child constitutes an indication for exploration and excision.

Excision is best performed under endotracheal anesthesia. A transverse incision is made over the lower pole of the cyst, and the incision is carried through the



Figure 69. A branchial cyst beneath the left side of the mandible.



Figure 70. The resected specimen from the patient in Figure 69.

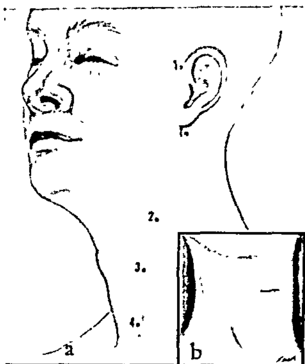



*Figure 71. a,* The opening of the branchial sinus on the skin and the corresponding branchial cleft from which the sinus developed are indicated by the numbers. *b,* A draining sinus following surgical incision.

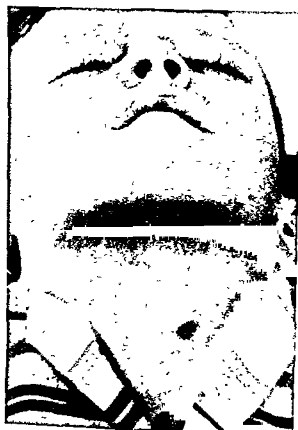


Figure 72. A thyroglossal sinus opening lateral to the midline.

platysma. Retraction of the sternocleidomastoid muscle posteriorly provides excellent exposure. The cyst is then dissected upward toward the pharynx. It sometimes passes between the external and internal carotid arteries to the pharynx. When the cyst parallels the entire length of the sternocleidomastoid muscle, multiple transverse incisions are probably preferable to a longitudinal incision, as the latter results in a greater cosmetic deformity.

The former practice of injecting a sclerosing substance in an effort to obliterate the cyst has been abandoned.

An *infected* cyst requires incision and drainage before it is excised. A lapse of about 6 to 8 weeks should be allowed after the infection has subsided, after which excision should be performed to prevent recurrence or sinus formation.

### THYROGLOSSAL CYSTS AND FISTULAS

***Etiology and Pathology.*** Thyroglossal cysts and fistulas are the result of developmental anomalies of the thyroid gland. The thyroid gland develops from a median diverticulum in the floor of the pharynx and from two lateral diverticula from the fourth pharyngeal pouches. Thyroglossal cysts and fistulas arise from this median diverticulum, which develops about the fourth week of fetal life in the floor of the pharynx and grows downward to form subsequently the isthmus and part of the lateral lobes of the thyroid gland As the diverticulum develops, it acquires the appearance of a duct, lined by respiratory (ciliated, columnar) epithelium. Normally, the duct becomes obliterated prior to birth, but its persistence may give rise to the foregoing anomalies. The tongue develops later than the pharyngeal diverticulum and grows around the latter. The cranial origin of the thyroglossal duct is, therefore, marked by a depression or orifice in the midline on the dorsum of the tongue—the foramen cecum The lower end of the duct forms the pyramidal lobe of the thyroid.[11] There is no opening to the skin of the neck from this duct.

Another embryologic phenomenon of importance is that the hyoid bone develops after the diverticulum is formed. It may pass behind, in front of, or around the diverticulum and is frequently intimately attached to the residual thyroglossal duct.

Defects in this developmental pattern may lead to abnormalities of the thyroid gland or of the thyroglossal duct at any point between the foramen cecum of the tongue and the lower portion of the neck. If the duct becomes obliterated cranially, a thyroglossal cyst may develop. If it remains patent, a fistula results. There may thus be a cyst at any level of the tract, just as there may be a hydrocele at any level of the spermatic cord and testicle. Thyroid tissue may be found in the wall of the cyst or may occur along the tract, as at the foramen cecum in the tongue (lingual goiter), without an associated cyst.

Following pressure and infection, metaplasia of the lining epithelium occurs, resulting in cuboidal or squamous epithelium. Nachlas[12] reported a squamous cell carcinoma developing from the thyroglossal duct, but this complication is extremely rare.

***Clinical Manifestations — Diagnosis.*** The diagnosis of thryoglossal cysts is based primarily on the development of a midline cystic mass in the neck. The cyst may steadily enlarge or it may fluctuate in size. It characteristically produces minimal discomfort unless it becomes infected.

The patient is usually young, in one-third of cases under 10 years of age[13] (Fig. 73). Often, however, the cyst may not be detectable for many years until secretion in later life makes it demonstrable (Fig. 74). The mechanism for this phenomenon is obscure and cannot always be explained on the basis of infection or trauma.

The cyst may occur at any level along the duct. Most are below the hyoid bone, between the hyoid bone and the thyroid gland. Sometimes, however, they are submental, above the hyoid. Approximately 4 per cent are confined to the substance of the tongue.[14] The cysts are characteristically located in the midline but may also occur slightly to either side. They

are freely movable beneath the strap muscles and are usually nontender.

Dyspnea and respiratory obstruction due to tracheal pressure in children have been reported but are rare manifestations.[12] Fistulas may periodically discharge into the oral cavity. Infection may be the primary manifestation, usually following an infection of the upper respiratory tract. In such cases, tenderness is the chief complaint, although other signs of inflammation are also present.

The thyroglossal sinus is an acquired lesion but is frequently present when the surgeon first sees the patient. It is the result of spontaneous perforation of an infected cyst or the sequela of incision and drainage. When the sinus closes, the cyst almost inevitably recurs.



*Figure 73* Thyroglossal duct sinus located in the midline, resulting from perforation of thyroglossal duct cyst.

A cystic mass, in or near the midline of the neck, which moves upward with protrusion of the tongue or swallowing, is almost certainly a thyroglossal cyst. It can be distinguished from the midline *aberrant thyroid* nodule only by its soft, cystic consistency, since the thyroid nodule, like the cyst, may occur at any point in the descent of the duct from the tongue to the suprasternal notch. The *branchial cysts* occur laterally along the anterior border of the sternocleidomastoid muscles and are often fixed to the skin at their lower border. *Dermoid cysts* rarely occur in the midline of the neck, but when they do, they can hardly be distinguished clinically from the thyroglossal cyst. The *cystic hygroma* occurs laterally and is more frequently low in the neck. *Submental adenitis* can usually be differentiated from an infected cyst by its submental position, the history of a focus of infection and the firmness of the adenitis.

***Treatment.*** The only treatment of thyroglossal cysts and fistulas is total excision. As in all other congenital defects, this should be done as early in life as

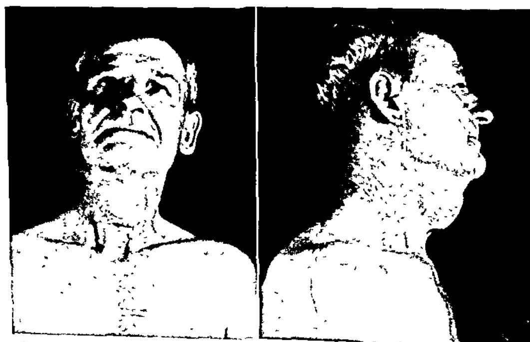


*Figure 74.* Thyroglossal duct cyst, located in the midline immediately above thyroid.

possible, to avoid subsequent complications. If infection is present when the patient is first seen, incision and drainage should be performed through a short transverse incision, followed a few weeks later by excision of the sinus and cyst to prevent recurrence.

Excision can be performed under local anesthesia but should pereferably be performed under endotracheal anesthesia with the patient hospitalized. A transverse incision is made over the lower portion of the cyst, the platysma is divided, and the strap muscles are retracted The cyst should not be perforated until its extent has been fully ascertained. Prevention of recurrence depends upon completeness of the excision. This requires excision of the central portion of the hyoid bone.[15, 16] The tract should be followed to its cranial limits, which may be at the foramen cecum. The hyoid defect need not be repaired, as no functional defect is detectable. Drainage is not necessary if hemostasis is adequate and reapposition of tissue is complete.


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*Chapter 8*

# Tumors

*By Denton A. Cooley*

### THE SEBACEOUS CYST
(Wen, Steatoma, Atheroma)

A typical sebaceous cyst or wen is a retention cyst formed by occlusion of the duct of a sebaceous gland in which the continued accumulation of secreted sebum, together with desquamated cells and cornified detritus, gradually distends the pore or hair follicle which, unless evacuated, may attain considerable size. The varied character of the cystic contents accounts for the multiplicity of descriptive terms applied to these lesions. Thus, a steatoma or atheroma is a cyst containing cholesterol crystals whereas a keratoma, which is thought to arise in the duct of the sebaceous gland, contains primarily cornified material. Inasmuch as the lesions are mostly similar clinically, no attempt need be made to differentiate them on this basis.

Characteristically, the sebaceous cyst is a subcutaneous globular mass protruding slightly above the level of the surrounding skin. The point of attachment (puncta) to the epidermis may often be demonstrated as a distinct dimple on the surface of the skin and represents the cutaneous opening of the occluded duct (Fig. 75). Occasionally a plug of sebaceous material may be visible in the puncta. Movement of the cyst causes dimpling of the skin at the puncta and serves to establish the diagnosis and differentiate it from a lipoma, which usually causes multiple dimpling of the skin when manipulated. Ordinarily the cyst is attached only to the skin and moves freely over the underlying fascia and bone, and is slightly fluctuant owing to the semi-solid nature of the contents. Most commonly there are no symptoms, the patients seeking treatment for cosmetic reasons. If infection supervenes, the cyst becomes tender and inflamed

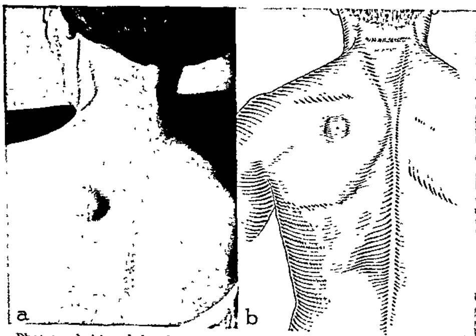



*Figure 75.* Photograph (*a*) and drawing (*b*) of a typical sebaceous cyst or wen in the interscapular region of the back showing characteristic "puncta" where cyst is attached to the skin.

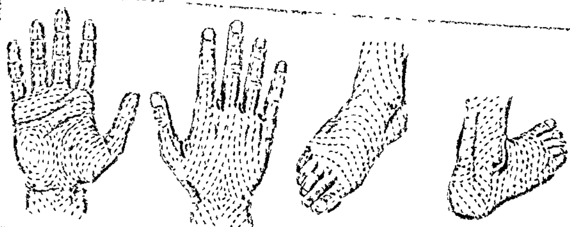


*Figure 76* D... best cosmetic a... Kitlowski· Arch ... Langer. In general for ... these lines. (Davis and

and fluctuation becomes more prominent as the cyst contents become more fluid and an abscess develops.

Sebaceous cysts may be only the size of a pea or they may become large as an orange. The lesion may occur anywhere on the body surface where there are sebaceous glands. Areas most frequently involved are the scalp, neck, back, scrotum or vulva, and cysts may be multiple in these areas. Sebaceous cysts are more commonly seen in elderly people but may occur at almost any age, particularly after puberty.

The complications of sebaceous cysts are infection and malignant change, the former being relatively common whereas the latter is infrequent or rare. When infection occurs it is usually due to the staphylococcus, which is a common skin contaminant.

The incidence of carcinoma in sebaceous cysts is probably less than 1 per cent, although Caylor[1] reported, in a series of 236 cysts removed at the Mayo Clinic, carcinoma in 3.44 per cent, and Bishop[2] found carcinoma in 9.2 per cent of his series of 119 cases. Carcinomatous sebaceous cysts are more frequently encountered in the female than in the male and epitheliomatous changes are more likely to occur in chronically infected cysts and in areas where there is considerable skin irritation. For the most part, cosmetic considerations rather than the dangers of malignancy are the prime indication for surgical removal of sebaceous cysts, particularly if the cyst is located on an exposed surface of the body, such as the face or scalp.

*Treatment.* In general, treatment requires total surgical excision with particular attention to removing the sac as completely as possible. If the cyst is already acutely inflamed at the first examination, nonoperative management should be employed for a few days. Warm compresses and antibiotics may cause a local cellulitis to subside completely. If an abscess results, however, incision with complete evacuation of the cyst contents should be done, usually with local ethyl chloride spray for anesthesia. Some cysts are permanently cured by evacuation and marsupialization, but in most instances subsequent total excision is necessary after the inflammation has subsided.

In removing a cyst, meticulous surgical technique is mandatory to insure pri-





*Figure 77.* [illegible]
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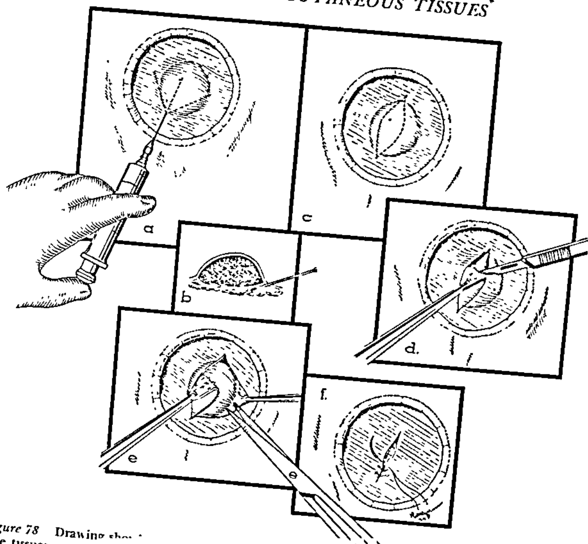



*Figure 78* Drawing sho... of the tissues surrour... *c* and *d* An ell... puncta ... sible *f*, ... per cent solution ... of skin including the nonabsorbable sutures ... are controlled with fine catgut ligatures ... ection purposes the cyst is removed intact if possible and the skin incision is closed with

mary healing and a satisfactory scar. The skin is shaved over a suitably wide area and then thoroughly cleansed with antiseptic solution according to the hospital routine for any sterile surgical procedure. The surgical field is draped with sterile towels. The direction of the incision must be carefully planned to insure a good cosmetic result. An incision following the lines of normal tension of the skin, as described by Langer,[3] will usually provide a satisfactory final result (Fig. 76). Incision on the face and neck should be planned to follow the natural skin creases (Fig. 77).[4]

Local infiltration with a 0.5 per cent solution of procaine hydrochloride around and deep to the cyst provides most satisfactory anesthesia (Fig. 78). Addition of one or two drops of a 1:1000 solution of epinephrine (for its vasoconstrictive effect) to each ounce of procaine solution tends to prolong anesthesia and to reduce bleeding in vascular areas.

An elliptical incision is made over the convexity of the cyst (Fig. 78). This permits excising the puncta and, where the overlying skin is thin, helps to avoid perforating the cyst by utilizing the attached skin to provide traction during the dissection. Removing the ellipse of skin with the specimen usually eliminates redundancy of the skin edges after the cyst has been removed. A plane of cleavage is developed outside of the cyst wall. By careful sharp and blunt dissection with a scissors and hemostat, the cyst

may be enucleated without perforating it. If the cyst is inadvertently opened, the contents should be expressed completely and sponged away and the cyst wall completely removed. Bleeding points are ligated with fine, plain catgut and the incision in the skin is closed with nonabsorbable sutures. If there is a question of infection in the wound or if the cyst is accidentally perforated during the dissection, it may be desirable to leave a small soft rubber drain in place for 24 hours. A dry, sterile dressing is applied and held in place with adhesive tape or collodion.

Alternative methods of treatment may be indicated when individual excision is impractical because of multiple cysts, which may occur in the beard, for example, or in cases in which the plane of cleavage may not be clearly defined. Under such circumstances a method of electrocoagulation of small cysts may be useful (Fig. 79). The diathermy needle is plunged into the cyst, coagulating the tissue about the needle and producing local necrosis. Several days later a plug of tissue falls out, establishing permanent drainage and marsupialization of the sac. The wall of the cyst, which is composed of squamous epithelium, becomes cornified and ultimately conforms to the surrounding skin in texture and color. Although this technique may be satisfactory for multiple small cysts, the cosmetic results following total surgical excision of larger cysts are preferable.

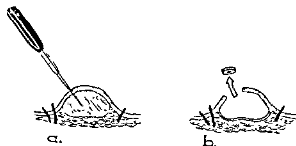
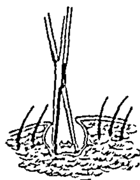






*Figure 79.* Drawing showing method of electrocoagulation of sebaceous cysts, a technique which may be useful where the lesions are multiple. *a*, The diathermy needle is inserted into the cyst cavity, and the electrocoagulating current is applied. *b*, Necrotic plug of tissue subsequently drops out and the contents of the cyst are evacuated. *c*, Base of cyst ultimately becomes cornified and conforms to level of adjacent skin.



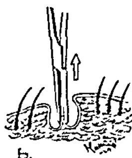



*Figure 80.* Drawing showing alternative method of removal of sebaceous cysts which is occasionally useful for scalp lesions. *a*, An incision is made into the cyst, the contents are evacuated, and the base of the cyst is grasped with a hemostatic forceps. *b*, The sac is avulsed by steady traction on the forceps. Careful surgical excision remains the treatment of choice (Fig. 78).

Another method of surgical removal, particularly applicable to cysts on the scalp, is to make a deliberate incision into the cyst itself, evacuate the contents, and then grasp the wall of the cyst with a hemostat and avulse it by traction and eversion of the sac (Fig. 80). Although a cyst is often completely removed by this simple maneuver, the method is not recommended routinely because of the tendency to leave fragments of cyst wall with the likelihood of subsequent recurrence.

### DERMOID AND EPIDERMOID CYSTS

***Dermoid Cysts.*** These lesions of the skin represent subcutaneous inclusions of dermal elements which occur from misplacement of embryonal ectoderm along lines of fusion with other embryonic layers. The inclusions are most likely to occur at the mid-dorsal and midventral lines and at the branchial clefts. The pilonidal cyst which occurs in the postanal region is the commonest dermoid, and because of its prevalence



*Figure 81* Photograph of patient with dermoid cyst located in characteristic position above the eyebrow.

it is considered in a separate section of the text. The dermoid cyst, a developmental anomaly, is present at birth although its presence may not be noticed until after puberty. Dermoid cysts may occur almost anywhere on the head and neck, but the floor of the mouth and the region just above the eyebrows are sites of predilection (Fig. 81). A dermoid cyst is usually covered with normal freely movable skin, in contrast to a sebaceous cyst, which is attached to the skin at one definite point. Moreover, a dermoid cyst is usually fixed to the underlying fascia or periosteum. Dermoid cysts of the ovary, testis, mediastinum and vital organs may contain hair and teeth and thus represent teratoid tumors. These lesions may become quite large and are major surgical problems.

The treatment of cutaneous dermoids is excision, usually for cosmetic reasons. General anesthesia may be advisable in all but the simplest lesions because of the tendency of these cysts to be deeply attached. Dermoids above the eyebrow may have a deep attachment to the meninges through a perforation of the skull, and if caution is not exercised in the dissection, a spinal fluid fistula may be produced. For this reason dermoids above the eyebrow should not be treated in the outpatient. Sharp dissection with a scalpel under constant vision is usually necessary for total removal of the lesion. The technique of excision of dermoids is otherwise the same as that of sebaceous cysts.

***Epidermoid Cyst.*** This epithelial lined cavity located in the subcutaneous tissue is usually caused by traumatic implantation of bits of epithelium below the epidermis, although occasionally the cyst may originate in an embryonic cell rest. Puncture wounds of the skin account for most of these which result from trauma, and the cyst may not appear for years after initial insignificant trauma.[5] Thus, they are encountered most often on the fingers and palms of laborers or people who handle pointed objects in their trade. Curiously enough some of these lesions have even appeared in bone. For the most part, subcutaneous implantation of epithelial fragments by puncture wounds is uncommon; for example, it rarely if ever occurs after hypodermic injections. Although these lesions usually cause no symptoms, occasionally they may become quite tender and cause considerable inconvenience, especially if they involve the skin of the hands or fingers. The tendency to malignant degeneration is slight. Epidermoid cysts should also be removed under local anesthesia by the same technique as described for sebaceous cysts.

## WARTS

**(Cutaneous Wart, Verruca Vulgaris)**

Warts are papillary, benign growths appearing on the exposed surfaces of the skin, characterized by hypertrophy of the horny layer in addition to increased length and irregularity of the papillae. They vary in size from pinpoint to more than 1 cm. in diameter and may be sessile or pedunculated. The surface is usually rough and irregular, with a shaggy appearance caused by excessive overgrowth of the papillae. Warts usually occur on exposed surfaces on the fingers, hands and face, and most frequently on persons from 5 to 15 years of age. On

the fingers they frequently appear in the periphery of the nails or even under the nails, and may be single, grouped or confluent. They may appear and disappear spontaneously without apparent reason.

Acuminate warts (venereal warts) are fungating lesions which occur on the genitals and around the anus in both sexes. (See pp. 316, 422.)

Plantar warts (see p. 255) (Fig. 82) are similar to the common wart in many respects but because of their characteristic location on the plantar aspects of the foot, overlying the metatarsal heads, and because of their tendency to produce disabling symptoms, they deserve special consideration. Plantar warts have a tendency to extend deeply into the hypertrophied skin of the foot, forming lesions painful to touch and to walk on. They may be distinguished from calluses and corns by close examination after the surface of the lesion is pared away with a scalpel. This maneuver will expose the distinguishing feature of these lesions, which is a characteristic central core. On the pared surface freshly bleeding capillaries representing the capillary projections may be seen, or these vessels may be thrombosed, in which case multiple brownish dots will be visible. In callosities there is no break in the normal capillary lines, and in corns, paring of the lesion exposes a central pearly grey cornified core without capillary vessels. Direct pressure over corns and callosities causes pain, whereas lateral pressure upon a plantar wart is more likely to elicit pain. Plantar warts occur usually in patients between the ages of 10 and 40 years and are often associated with flattened arches and ill-fitting shoes. Occasionally, warts are seen growing in corns or callosities.

The etiology of all warts has not been definitely established, although the theory that implicates a filterable virus is most plausible. Warts have been inoculated in human beings and in animals, and the infective agent will pass through a bacterial filter. Typical common warts have been produced by intracutaneous injection of a sterile filtrate of wart material. The incubation period is usually from one to eight months, depending upon the susceptibility of the individual. Perhaps all warts are caused by a filter-




*Figure 82.* (*A*) Photograph showing simple callus of foot located under prominence of second metatarsal head. (*B*) Photograph showing large plantar warts and surrounding callus on weight-bearing surface of foot. (Courtesy of Dr. John Knox, Division of Dermatology, Baylor University College of Medicine.)

able virus, but the size, extent, location and distribution depend upon certain factors which are determined by susceptibility of the host and location of the inoculum.

*Treatment.* The methods of treatment of warts are numerous, but only the more effective means will be considered. Many fascinating means of dealing with these lesions have been proposed and used, most of which represent forms of psychotherapy. Good results from such treatments have been vaguely attributed to alterations produced in the vegetative nervous system or even the endocrine system. For example, apparent cures have been forthcoming with hypnotic suggestion of various types. In some instances warts have disappeared following mental suggestions by means of highly colored liquids, magic wands, charms and other devices. Also, there is convincing evidence that certain accepted methods of treatment, such as irradiation, bismuth injections, and even electrodesiccation, are merely variations of suggestion therapy. Systemic treatment, consisting mainly of intramuscular injections of bismuth subsalicylate, continues to have advocates, and local injections of similar substances sometimes produce a cure. Although these methods of treatment may occasionally be successful, their usefulness is nevertheless limited.

Electrodesiccation offers the most effective means of treatment for warts involving the hands and face. After the skin has been cleansed with soap and water, the lesion is painted with an antiseptic solution and infiltrated with 0 5 per cent solution of procaine. With the electrodesiccating cautery point sufficient tissue in the lesion and in the immediate surrounding zone is coagulated to destroy the lesion and its cutaneous projections. Small scissors may be used to trim away the charred tissue, and if necessary, more adequate coagulation may be performed unless it has been demonstrated that the depths of the lesion have been adequately coagulated. In some instances, recauterization is necessary six to eight weeks later if cure has not been obtained by the first treatment.

Local application of strong acids or alkalies, such as nitric, chromic and trichloracetic acids, phenol and glacial acetic acid in concentrated liquid form, may be effective in some instances. Repeated application of those substances may in time entirely remove the wart but their use must be cautiously controlled.

The treatment of plantar warts deserves special consideration because of their troublesome location and their striking tendency to recur after treatment. Conservative management consists of paring down the adjacent callus to expose the core of the wart. Daily applications of a 10 per cent solution of salicylic acid in collodion or a 10 per cent salicylic acid ointment will keep the lesions soft and relieve pain, which is caused by pressure from the hard core. Because weak arches or prominence of the second metatarsal head may predispose to plantar warts, the patient should wear properly fitted shoes with metatarsal arch supports, and in time the wart may completely disappear. (See Orthopedic section, p. 255.) If such measures are not successful, electrodesiccation may be effective, although occasionally a painful scar results. Electrodesiccation should be done carefully in order to avoid a severe plantar burn, which may be temporarily crippling. More obstinate warts require wide local excision under spinal or general anesthesia, with primary suture or skin graft to close the defect.

Radiotherapy has been widely used and, unfortunately, in some instances inadvisedly, with serious consequences Large warts on the back of the hand may be effectively removed by electrodesiccation followed by administration of x-radiation closely shielded to the edge of the wart. In general, however, radiotherapy, including roentgen ray and radium, should be confined to treatment of plantar warts, largely because irradiation, and especially radium, tends to produce unsightly telangiectasis. A method for treating plantar warts, effective in 60 to

80 per cent of cases, is a single application of 1600 r shielded to within 1 to 2 mm. of the edge of the wart after the lesion has been pared to expose its core. Management of complicated plantar warts requires the advice of a skilled radiologist-dermatologist.[6-8]

Treatment of venereal warts (condylomata acuminata) is described in the chapters on the anus and perianal regions and the male and female genitourinary systems.

### PAPILLOMA

Like the wart or verucca, papilloma of the skin (Fig. 83) arises from the superficial layers of the skin and is a benign lesion. The papilloma is also probably caused by a filterable virus. In general, the papilloma shows no malignant tendencies, but, as in other benign lesions under stimulus of chronic irritation, may develop into a carcinoma. Depending upon their location, papillomas should be removed under local anesthesia by excision or fulguration.

### KERATOSIS
(Keratosis Senilis, Seborrheic Keratosis)

These are flat, dry, circumscribed lesions with a roughened surface, characteristically located on parts of the body which are usually exposed to actinic rays of sunlight (Figs. 83 and 84). There are several forms, varying from simple keratoses, which, after reaching a certain gradation of maturity, drop off the skin, to those which progress rapidly into advancing squamous carcinomas. Keratoid keratosis, which is flat and verrucose, is produced by proliferation of the epithelium, the structure of which may exhibit a loose arrangement with a surface from which flakes of tissue can be dislodged. In some instances exuberant epithelium may have a striking cohesiveness and may form a yellowish cutaneous horn of cartilaginous consistency. Benign forms of keratosis have little evidence of increased vascularity, whereas the faster growing lesions with cancerous tendencies are characteristically surrounded by a narrow zone of hyperemia. About 15 per cent of these lesions are reported to progress to squamous carcinoma.

Treatment varies with the location of the keratosis but usually requires either a series of local applications of keratolytics, electrodesiccation or excision. An ointment consisting of 10 per cent salicylic acid and petrolatum base may soften the keratosis and appear to destroy it, although in many instances the cells below the skin level continue to proliferate. Healing will occur in most cases without evidence of cicatrization following fulguration with the electro-

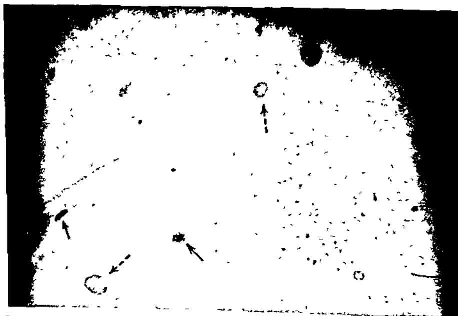


*Figure 83.* Photograph showing multiple papillomas (dotted arrows) and seborrheic keratoses (solid arrows) on back of elderly male.

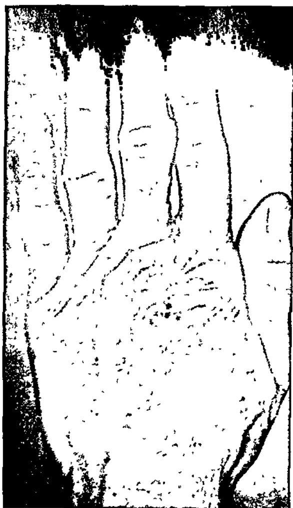


*Figure 84* Photograph of hand showing senile keratoses.

desiccating needle Because of the malignant potentialities in some of these lesions, total excision, including a narrow margin of normal skin, may be indicated when feasible. If histologic examination of the margins of the lesion reveals cancer, the margins of excision must be enlarged. In some instances dermatologists have obtained admirable results with irradiation or radium application. Dermatitis may occur at the site of the lesion and may require subsequent excision.

## KELOIDS

Keloid may be defined as overgrowth of connective tissue arising usually in scars formed after lacerations, excisions, puncture wounds or in draining sinuses. The lesion, which is usually raised above the surface of the skin, presents a reddened, shiny surface, and is sometimes painful. It may be difficult to differentiate between a normal degree of scar tissue formation and excessive fibrous growth in a healing wound, but in some instances the overgrowth of fibrous tissue may be extreme, forming small pedunculated growths. Microscopically, the fibrosis is located in the layers of the cutis. The stimulus to overgrowth of fibrous tissue in a wound or ulcer depends upon several factors. Although the etiology is not definitely known, keloids more commonly appear in an infected and granulated area such as in the draining sinuses, in tuberculous glands of the neck or in the granulations of a deep, cutaneous burn. Keloids are likely to occur on the anterior chest, particularly in women, because of the tension produced by the breasts. Certain individuals appear to have a predisposition to keloid formation, and under these circumstances the tendency may be hereditary. The Negro race is particularly prone to keloid formation (Fig. 85).

There are several stages in the development or maturation of keloids. In the initial stage the lesion is reddened, smooth and glistening, with a translucent surface beneath which small capillary-sized vessels are visible. After four to six weeks, a stage of involution begins to appear and the surface of the keloid becomes wrinkled, indicating some subsidence of edema and inflammatory change. The final stage in maturation appears, and the surface changes from red to white, edema completely subsides, and areas of brownish pigment become evident on the surface Malignant changes almost never develop in the excessive fibrous tissue of keloids despite the striking fibroplastic activity. The undesirable effects result from the presence of unsightly scars on exposed surfaces of the body or incapacitation caused by contractures which may follow deep cutaneous burns of the axilla and antecubital or popliteal space. Surgical treatment of keloids is generally not satisfactory, partly because the etiology is unknown and partly because of an apparent tendency to keloid formation which is present in some individuals During the first six to eight weeks of healing, the appear-

ance of a scar may strongly suggest keloid formation, but after a longer period of time has elapsed the scar may be satisfactory enough to require no treatment. Thus, it is advisable to postpone treatment for four to six months before surgical excision of a scar is considered.

In special cases, particularly in young women who may express considerable concern over the lesion, treatment may be instituted earlier. Usually the most satisfactory results are obtained by a combination of surgical excision of the lesion and irradiation. Particularly in persons who are susceptible to keloids, meticulous technique must be employed in excising the lesion to avoid unnecessary operative trauma. Extensive lesions require general anesthesia, whereas smaller ones may be removed after infiltration with procaine solution. The edges of the wound are approximated carefully with fine nylon sutures. If an extensive excision has been necessary, a split thickness graft may be utilized. Small doses of irradiation for the first four to five days postoperatively may be beneficial, particularly if primary closure has been done. Despite this, recurrences are common. Surgical treatment of extensive keloids causing contractures of the axilla, popliteal space and neck are strictly major surgical problems and are considered in a separate section.

### FIBROMAS

Fibromas are benign tumors of fibrous tissue origin which may appear anywhere on the body surface. They arise in the deeper layers of the skin and frequently contain other mesodermal or epithelial elements; hence such terms as fibrolipoma, myofibroma and neurofibroma have been applied to them. A fibroma with a gelatinous type of stroma is referred to as a fibromyxoma. Under ordinary circumstances the tendency to malignant changes is relatively slight, but any lesion exposed to constant trauma may ultimately become malignant. Thus, excision may be indicated in a small fibroma in constant contact with a man's collar or belt, whereas the same kind of lesion in a location not subjected to constant trauma may require no treatment. Neurofibromas in the thorax and within the abdomen are particularly susceptible to the development of malignant change. Surgical excision is also indicated if the lesion is painful, or for cosmetic reasons, and removal for biopsy may be indicated.

The technique of excising such cutaneous tumors is simple. As for epidermoid cysts, the line of incision is planned to conform to the natural creases of the skin. Following infiltration of the surrounding area, the lesion is removed with a small margin of normal tissue.




*Figure 85.* *a*, Photograph of Negro patient demonstrating keloid tendency with hypertrophied scars at sites of previous lacerations *b*, Photograph of patient with large keloid resulting from practice of ear-piercing




*Figure 86* a and b, Photograph of patient with neurofibromatosis (von Recklinghausen's disease). The lesions covered the entire body and caused no symptoms Operative scar on back was from previous operative removal of left upper lobe for pulmonary tuberculosis.

The skin edges are re-approximated with fine sutures of nylon.

Neurofibromatosis (von Recklinghausen's disease)[9] is an easily recognized systemic condition which is usually hereditary in origin. It is characterized by the presence of multiple tumors of varying sizes, areas of cutaneous pigmentation, and café au lait patches (Fig. 86). The tumors are sometimes painful and are usually visible, projecting above the cutaneous surface, but may be palpable under the skin. The fibrous tumors arise on the nerve sheath or neurilemma. In some instances, the neurofibroma involves primarily the axis cylinder and then causes thickening, tortuosity and elongation of the nerve. This type of tumor is referred to as the plexiform neurofibroma.

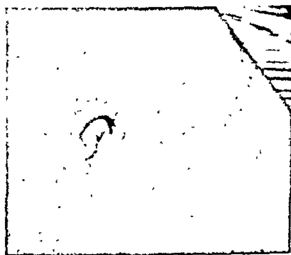


*Figure 87.* Photograph showing café au lait pigmentation, patches on skin near umbilicus. (Courtesy of Dr. John Knox, Division of Dermatology, Baylor University College of Medicine.)

Neurofibromas may occur in many sites other than the skin surface, including bone, central nervous system and pelvis. They vary in size from that of a pea to that of a large grapefruit, and though usually painless, occasionally these tumors may cause considerable discomfort. Pigmentation is an important diagnostic feature of this disease. Patches of light brownish pigmentation (café au lait) on the skin surface (Fig. 87) may suggest the diagnosis when cutaneous lesions are absent. Some neurofibromas become sarcomatous and unless completely removed may be fatal. Malignant degeneration should be suspected if lesions attain unusually large size or show recent tendency to rapid growth and if paresthesia, hyperesthesia or motor changes appear spontaneously. Under such circumstances excision is indicated.

It is usually impractical to attempt excision of multiple lesions of neurofibromatosis because of their widespread

distribution. In general, the tumors on the face and other exposed parts of the body probably should be excised, but no attempt should be made to remove lesions of generalized distribution. The nature of the disease should be explained to these patients so that they may be reassured and learn to tolerate their disfigurement.

### LIPOMAS

Lipomas are benign tumors originating in fatty tissue and varying in size from several millimeters in diameter to several pounds in weight. Lipomas located deeper in the body, as in the mesenteric or retroperitoneal tissues, tend to become immense before removal. On the cutaneous surface these tumors are lobulated and usually the lobules are surrounded by a fibrous capsule. There is no tendency for fatty tumors to spread outside their capsule, but as they slowly grow, they may cause discomfort by compressing surrounding structures. Although they rarely become malignant, in doubtful cases surgical excision is indicated.

The commonest sites of lipomas on the body surface are in the subcutaneous tissues of the shoulders, back, upper arm and buttocks, particularly in obese persons. The tumors are usually not tender and the lobulations are easily palpated. In some instances there may be difficulty in differentiating lipomas from sebaceous cysts; the tendency for fibrous trabeculae to cause multiple dimpling of the skin on movement of lipomas may assist in differentiation (Fig. 88). The skin overlying the lipoma may have an "orange skin" appearance produced by the deep fibrous attachments. Lipomas have a fluctuant feel and resemble on palpation a fluid-containing cyst. A large tumor or one pressing on nerves may cause pain, but usually multiple, painful lipomas in obese persons indicate the diagnosis of a rare disease known as adiposis

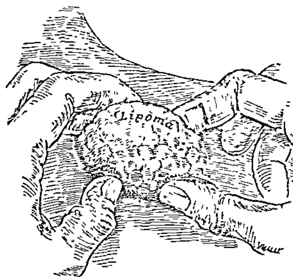



*Figure 88* Drawing showing multiple dimpling of the skin overlying a lipoma revealed by lateral compression of the base of the tumor between the fingers.



*Figure 89.* Photograph of patient with adiposis dolorosa (Dercum's disease), exhibiting multiple fatty tumors of the trunk and extremities which were intermittently painful and tender.



*Figure 90* Photograph showing xanthelasma Xanthomas involve medial aspect of both upper lids

dolorosa (Dercum's disease) (Fig. 89). The pain is probably related to the proximity of the lipoma to the cutaneous nerve endings.

Treatment of lipomas is usually surgical excision. Local infiltration of procaine solution may provide sufficient anesthesia for small tumors. General anesthesia is preferable for excision of large lipomas, particularly those situated on the back where there are dense fibrous attachments to the underlying fascia, and where rather large vascular tributaries may be encountered during the dissection, requiring considerable operative manipulation.

Incision over the lipoma demonstrates a thin capsule delineating the various lobulations and trabeculae. By sharp dissection, the tumor may be completely removed intact. The remaining defect is obliterated by insertion of fine, plain catgut sutures attaching the skin flap to the underlying fascia. If the defect is extensive, it may be advisable to employ a small soft rubber drain for several days to prevent postoperative formation of a seroma.

### XANTHOMAS

Xanthomas are small, yellow, benign nodules in the skin thought to be produced by a disturbance of lipoid metabolism. They are usually located on the eyelids, and there are called xanthelasma (Fig. 90). They may be somewhat disfiguring, particularly when multiple, and may be carefully excised under local anesthesia with good results.

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# Tumors (Continued)

*By John W. Overstreet*

## THE GLOMUS TUMOR

The glomus tumor is a rare, benign, painful small neoplasm involving usually the skin and subcutaneous tissues.[1] It is found most often on the extremities. The neoplasm arises from the normally occurring glomus body which is a normal end-organ structure composed of an arteriovenous anastomosis without an intervening capillary bed. There is a neuroreticular component associated with the glomus body that is thought to control the rate of blood flow through the arteriovenous channels and thus to help regulate blood flow to the extremities and, in consequence, to conserve or dissipate body heat.

When the glomus apparatus is fully dilated there is a large dispersal of heat due to the greatly accelerated rate of blood flow. When the glomus is closed the heat is conserved by shunting blood through the capillary network and away from the skin. Popoff[2] found that there were 65 glomus bodies in the large toe alone, they being especially concentrated in the nailbed and distal phalanx. Therefore, it is not unexpected that the terminal phalanges of the toes and fingers should be the most common location of the glomus tumor; those occurring in the nailbed may be excruciatingly painful. Glomus tumors have occasionally been found in the dermis of other body areas, and one case of a mediastinal glomus tumor has been reported.[3]

The glomus tumor is small, usually single, and there is little evidence to suggest any racial or sex variation. Neither is there any significant age concentration, for the tumor has been found in the very young and the very old.

The tumor rarely measures over 1 cm. in size and is usually sharply demarcated and clearly visible; however, rarely it may be so small as to be impalpable, and only an exquisitely tender "trigger-spot" shows the location of the tumor. The tumor may vary in color from gray to blue to red and the color may change in extremes of temperature—blue in cold, reddish pink in the presence of heat. Pain of a particularly excruciating type is a characteristic feature of the tumor. The pain may be throbbing in character but more usually is lancinating, extending from the tumor up the entire extremity. The slightest touch or temperature change may set off the pain and the patient may be forced to take marked protective measures in order to carry on normal activities.

Rarely the glomus tumor may affect the bone of a terminal phalanx, leading to destructive changes secondary to pressure; however, the tumor is benign and does not metastasize.

Local surgical excision leads to complete cure of the glomus tumor; roentgenotherapy, heat, cold and sympathectomy are without benefit. Under local infiltration, regional nerve block or rarely general anesthesia, the tumor itself can usually be dissected free with minimal loss of normal tissue; however, when the bone of the terminal phalanx is eroded, local amputation may be necessary.

## CARCINOMA OF THE SKIN

Carcinoma of the skin is without question the most common form of cancer occurring in the human body. It occurs primarily in two forms, the basal cell carcinoma, or so-called rodent ulcer (Fig. 91), and the more malignant squamous cell or epidermoid cancer of the skin (Fig. 92). Skin carcinoma is also the most easily detected of all cancers and this is reflected in the excellent results that are obtained by intelligently applied therapy.

***Etiology.*** Carcinoma of the skin is found predominantly in outdoor workers



*Figure 90.* Photograph showing xanthelasma Xanthomas involve medial aspect of both upper lids

dolorosa (Dercum's disease) (Fig. 89). The pain is probably related to the proximity of the lipoma to the cutaneous nerve endings.

Treatment of lipomas is usually surgical excision Local infiltration of procaine solution may provide sufficient anesthesia for small tumors. General anesthesia is preferable for excision of large lipomas, particularly those situated on the back where there are dense fibrous attachments to the underlying fascia, and where rather large vascular tributaries may be encountered during the dissection, requiring considerable operative manipulation.

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*Clinical Manifestations.* Skin carcinoma, whether basal cell or squamous cell, may grow primarily as a polypoid projection above the skin level, as a deeply invasive ulceration, or by wide superficial lateral growth. The prognosis of the individual case may be considerably influenced by this particular aspect of the tumor. It has been shown that skin carcinomas which occur at or above the level of the sweat glands in the skin rarely metastasize, whereas those tumors that infiltrate definitely below the level of the coiled sweat glands may metastasize to the regional lymph nodes in as high as 30 per cent of the cases.

*Pathology.* Basal cell carcinomas arise from the basal layer of the skin epithelium and may present various histologic patterns. They may present as areas of solidly packed cells extending through the basement membrane into the deeper tissues, or they may be associated with masses of such cells surrounding cystic areas filled with mucin. Occasionally there may be areas of squamous cells showing keratinization, and this type is classified as a basosquamous epithelioma. Basal cell carcinomas most frequently develop from a pre-existing area of hyperkeratosis on the skin of the scalp, the nose, around the lips, the eyelids, the ears and the dorsum of the hands. They are usually well circumscribed, having a grayish white color, and although more commonly they show an exophytic type of growth, they may ulcerate and invade deeply with great destruction of skin, fascia, muscle, cartilage and bone. The latter type represents the so-called rodent ulcer. Basal cell carcinomas practically never metastasize, but may lead to death of the patient through secondary infection and hemorrhage. The rate of growth of these tumors is extremely slow.

Epidermoid carcinomas of the skin are no different histologically from squamous cell carcinomas occurring in other organs of the body. They show varying degrees of keratinization and pearl formation, depending upon the degree of anaplasia of the tumor. Epidermoid carcinomas usually arise from pre-existing areas of hyperkeratosis and are commonly found in the skin of the temporal and malar areas of the face and forehead and more particularly on the dorsum of the hands. Epidermoid carcinomas, although rarely found on unexposed surfaces of the body other than in areas of previous chemical or physical trauma, are much more likely to be found in these localities than are basal cell carcinomas. These lesions may be either protuberant or ulcerative. Those that ulcerate are usually secondarily infected and there may be a considerable zone of surrounding inflammation and fixation to the deeper structures, making it very difficult to determine whether the fixation is due solely to infection or to tumor infiltration.

Carcinomas may also arise in sweat glands and in sebaceous glands; however, only a few cases of each have been reported in the medical literature. They tend to grow slowly and to invade locally, and only very rarely metastasize.

*Diagnosis.* The diagnosis of carcinoma of the skin can be made clinically in a very great percentage of cases; however, the treatment of such a lesion should never be undertaken without previously having obtained a definitive diagnosis by means of an incisional biopsy and histologic diagnosis. An amelanotic melanoma may grossly appear identical with a nonulcerating basal cell carcinoma, and since the former lesion is completely radioresistant, the use of x-ray therapy without histologic diagnosis may lead to tragic results. In ulcerating lesions the biopsy should be taken from the edge of the tumor to include a segment of the normal-appearing skin, for otherwise infection may mask the underlying tumor and lead to an erroneous diagnosis.

*Treatment.* Skin carcinomas offer by far the best prognosis of any type of cancer; however, these tumors may kill by local destruction, by invasion or by distant metastasis just as surely as the most virulent cancer if they do not receive proper and competent treatment. Radiation therapy and surgical excision each give excellent results, and there is

Fig 91



Fig. 92

*Figure 91.* Photograph of excised basal cell carcinoma.

*Figure 92* Photograph of squamous cell carcinoma of neck.



*Figure 93.* Photograph of arsenical skin cancer of index finger.

or people who are exposed over long periods of time to the sun and wind. By far the greatest number of skin cancers occur on the exposed surfaces of the body, particularly the face, neck, ears and hands. Prolonged exposure to solar rays is apparently the most important etiologic factor concerned in the production of skin cancer. The incidence of skin cancer is relatively high in farmers, construction workers, sailors and fishermen. Prolonged exposure is necessary for the solar rays to exert their carcinogenic effects, for the disease is rarely seen before the age of 40 years and is most commonly found beyond the age of 60. Men do not seem to be more susceptible to the disease than do women, although the fact that the former are more commonly employed in outdoor activities is reflected in the incidence rate, some series having reported the disease as 7 times more common in men than in women. There is no appreciable sex or racial variance in those skin cancers occurring on the unexposed portions of the body. There is some racial susceptibility in that the races with light skins show a much higher incidence of the disease than do the dark-skinned races. Individuals with a hereditary hypersensitivity of the skin to the rays of the sun develop a condition known as xeroderma pigmentosum, which is associated with early development of multiple skin cancers. Characteristically, prolonged exposure to the sun's rays produces definite patches of hyperkeratosis which, after a varying length of time, is followed by the development of carcinoma.

Other important etiologic factors include previous damage to skin by excessive irradiation, burn scars, or chronic ulcers, such as decubiti and stasis ulcerations of the lower extremities.

Certain chemical agents have been shown to have the capacity to produce skin cancers, notable among these being arsenic. One of the characteristics of arsenical skin cancer is its frequent occurrence on the soles of the feet and the palms of the hands (Fig. 93), locations where skin carcinomas otherwise do not commonly arise. Chronic exposure to nitrites, oils, paraffin and other coal tar products has been implicated as a cause of skin cancer.

of the hand, not infrequently a well developed carcinoma will be present surrounded by an area of numerous hyperkeratoses. In such circumstances it is the preferred method of treatment to widely resect the carcinoma and the surrounding damaged skin and to replace the defect immediately with a split-thickness skin graft. This offers good functional and cosmetic results (Figs. 94 and 95).

Carcinoma of the skin offers by far the best prognosis of cancers affecting mankind. Intelligent therapy directed toward the lesions should result in a 5-year control rate of better than 90 per cent in basal cell carcinomas and better than 80 per cent in squamous cell carcinomas, and by earlier and more vigorous treatment of suspicious lesions these figures can be materially increased.

### MALIGNANT MELANOMA

The malignant melanoma, melanosarcoma or malignant mole is the most dangerous and yet the most unpredictable of all cutaneous neoplasms.

*Etiology.* There is considerable difference of opinion as to the incidence of this lesion but all are agreed that it is associated with high morbidity and mortality. It has been reported to comprise as high as 2 per cent of all malignancies and 20 per cent of all skin cancers. It is also the most common malignancy involving the lower extremities. The tumor occurs most commonly in the skin, arising from malignant change in a preexisting epidermo-dermal or "junctional" nevus (Fig. 96). However, it may arise anywhere in the body: in the eye, at the junction of skin and mucous membranes of the body orifices, and in the gastrointestinal tract, although it is extremely rare in the latter. The anatomic sites found to be most frequently involved, in general order of frequency, are the lower extremity, head and neck (Fig. 97), trunk, upper extremity and eye. Certainly a very small percentage of pigmented nevi represent malignant melanomas; however, those occurring in the eye, on the soles of the feet and the palms of the hands, beneath the finger and toe nails and on the genitalia should be strongly suspected of being malignant.

Although there has been some disagreement, Soldan's and Masson's thesis that melanomas are of neuro-ectodermal origin has been widely accepted. It is felt that the dermo-epidermal, or junction, cell is related to the Schwann cell of nerve tissue and the corpuscles of Meissner and Ranvier. About 95 per cent of all nevi in children have nevus cells in the epidermis and are therefore junction nevi. It has been estimated that about 15 per cent of these remain as junction nevi and it is from these that most cutaneous melanomas arise. The intradermal nevus or common brown nevus very rarely becomes malignant.

*Pathology.* The microscopic picture of malignant melanoma is very variable. In

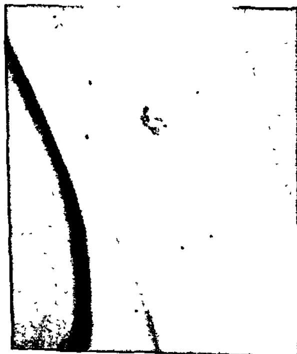


*Figure 96.* Photograph of junction nevus of leg.



*Figure 97.* Photograph of melanoma of cheek.

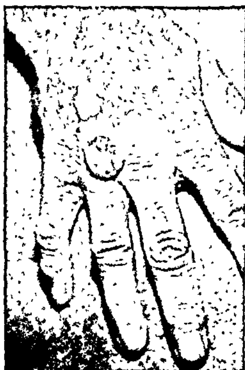


Fig 94



Fig. 95.

*Figure 94* Photograph of carcinoma of dorsum of hand with surrounding keratosis.
*Figure 95.* Photograph following excision and grafting of carcinoma of dorsum of hand in same patient depicted in Figure 94.

not a great deal to choose between the methods of therapy under usual circumstances; however, each has specific advantages in particular types of cases. Some lesions of the eyelids and those around the inner canthus of the eye, the nose and the nasolabial folds, and of the ears and lips may be treated just as successfully by x-ray as by surgery and actually yield a better cosmetic result. In other instances, particularly in skin carcinomas arising in previously damaged tissue from either physical or chemical trauma, surgery is the preferred method of therapy. Wide surgical excision, with at least a 1 cm. margin of normal skin at the periphery, should be done It should be stressed that with the use of surgery the depth of the excision is just as important as is the width of the excision. The full depth of the skin and superficial fascia must be taken in each case and if there is evidence of deeper invasion an adequate margin of tissue in the depth of the incision may be more important than is the clearance at the periphery, because recurrent tumor at the lateral margin becomes readily apparent whereas recurrence in the depth may be overlooked until wide extension has occurred. In some instances destructive amputation may be the only method of therapy available with hope of cure, owing to long-standing invasive disease. If the process has extended beyond hope of cure or if the patient refuses surgery, x-ray may offer significant palliation. Prophylactic node dissection is rarely indicated in these lesions; however, in those that show clinical evidence of metastasis to the regional nodes a radical resection of the lymph nodes should be carried out. In those lesions of squamous carcinomas which show deep invasion and a high degree of anaplasia it may be worth while to do a radical resection of the regional lymphatic drainage area even in the absence of clinically detectable metastasis. Obviously, such node dissections are in-patient hospital procedures under appropriate general or spinal anesthesia. Not infrequently a combination of therapy consisting of x-ray to control the local lesions and surgery to control the lymphatic metastasis may be used, this being commonly true in cases of carcinoma of the lip. In the treatment of carcinoma of the dorsum

removal of an eye for retinal melanoma without other demonstrable evidence of metastasis. The actual cautery, electric needle, radium or x-ray should never be used in the treatment of melanomas or melanotic moles of the dermo epidermal type.

All melanotic moles of the palms of the hands, soles of the feet, genital areas or beneath the finger or toe nails ("melanotic whitlows") should be removed with a wide segment of skin and underlying fascia, for the likelihood that moles occurring in these areas are malignant is great. Also all melanotic moles that are subjected to chronic trauma should be removed.

*Treatment.* It is generally accepted that radical surgical excision of the local lesion and the regional lymphatic reservoir is the only effective method of treatment of melanomas. There is some disagreement as to whether the excision should be super-radical to include quarterectomy, that is, hemipelvectomy in lesions of the lower extremity with obvious inguinal node metastasis, and interscapulothoracic amputation for lesions of the upper extremity with nodal metastasis. The latter concept has not received wide acceptance, most surgeons feeling that such operations are not likely to increase the salvage rate of such advanced lesions sufficiently to justify the increase in mortality and morbidity.

There is agreement that radical regional node dissection should be done in all cases regardless of whether such metastasis can be demonstrated. In subungual melanomas, amputation of the finger or toe with regional node dissection is indicated. In patients with genital melanomas, a very wide local excision should be done with bilateral inguinal node dissection. Anorectal melanomas should have a radical abdominoperineal resection followed by bilateral inguinal node dissection. Melanomas of the eye require enucleation. As previously stated, melanomas occurring before puberty, although histologically indistinguishable from adult melanomas, very rarely act clinically malignant and adequate local excision usually results in a cure. Should such a case show evidence of metastasis, it should be treated by radical surgical excision with regional node resection. Chemical perfusion of an extremity containing melanoma with nitrogen mustard or other alkylating agents using extracorporeal circulation to isolate the extremity temporarily and thus preventing bone marrow suppression is under extensive clinical investigation. The method shows some definite promise, but its use is too recent for definitive evaluation.

Owing to the behavior of most melanomas before puberty, it has been felt that they must be under some hormonal influence; however, this has not been substantiated and the treatment of advanced lesions by various hormones, gonad resection, bilateral adrenalectomy or pituitary irradiation has produced no cures and little evidence of effective palliation.

Statistical results of the radical treatment of malignant melanomas are hard to evaluate because there is no common denominator in such reports. However, reports of 5-year survival without evidence of residual melanoma have varied between 15 and 35 per cent, indicating that such results are comparable with the results of the treatment of many other malignancies. Early suspicion, adequate diagnosis by excisional biopsy, and well planned and executed radical surgery should materially increase the number of cures in this often misunderstood and by no means hopeless cutaneous neoplasm.

### FIBROSARCOMAS

The fibrosarcoma is one of a group of malignancies of mesenchymal origin which, because of various histologic components, are quite commonly grouped as "soft-parts sarcomas." If the fibroblastic elements predominate, the tumor is labeled a fibrosarcoma; however, in many instances multiple sections cut from such tumors will show various areas suggestive of fatty, muscular, neural or bony origin. It therefore is frequently extremely difficult to put these tumors into a separate definitive group. It is also quite common to find on multiple histologic sections

those tumors with large amounts of melanin and large round or oval cells with round nuclei, large nucleoli and bizarre mitotic figures, the diagnosis offers no difficulty. However, in those melanomas with very scanty pigment, the so-called amelanotic melanomas, with bizarre cellular patterns, the histologic diagnosis may be difficult and may require the study of numerous sections and the aid of the tyrosinase reaction and the Bloch dopa technique of staining to identify definitely the malignant cells. The malignant melanoma may mimic the histologic features of other malignant tumors such as fibrosarcoma with long spindle-like cells or a very undifferentiated carcinoma with small round cells, little cytoplasm and small nucleoli.

An interesting variant of the malignant melanoma is the one occurring in young children prior to puberty; although it may be histologically indistinguishable from the adult form, biologically it very rarely shows local extension or metastasis and thus the treatment and prognosis are quite different in these cases.

*Diagnosis.* The clinical diagnosis is usually not difficult to make, but it must be stressed that definitive treatment of this lesion should rarely be undertaken without prior histologic proof by surgical biopsy. Scantily pigmented melanomas occurring in the preauricular area and along the hair lines can be easily mistaken for a basal-cell epithelioma, and with tragic results if the treatment for the latter condition is instituted

Any of the following changes in a previously quiescent mole should suggest malignant change (1) increase in size, (2) change in color, (3) infection, (4) bleeding or ulceration, (5) pain or any irritation, or (6) development of a halo or satellite moles.

The development of regional and nodal enlargement without obvious cause should lead one to examine carefully the lymphatic drainage area for the presence of a suspicious-appearing mole. In about 10 per cent of reported cases, clinical evidence of regional node involvement has been the initial sign of the presence of a malignant melanoma.

Malignant melanomas may spread by local extension, by the lymphatics to show satellite areas and nodal metastasis, and more frequently by the blood stream to the lungs, liver, brain and bone. In the far advanced lesions no organ system or structure may escape metastatic lesions. In very small suspicious lesions, excisional biopsy using field block or general anesthesia, and including at least 2 cm. wide skin margins and the full thickness of subcutaneous fat and fascia, should be done. Local infiltration anesthesia under the tumor should not be used for fear of producing tumor emboli. In the large cutaneous lesion a small incisional biopsy taken from the edge of the lesion may be preferable. If the diagnosis of malignant melanoma is made, a very thorough search for metastasic spread and a complete general evaluation of the clinical status of the patient should be made before further definitive therapy is decided upon. The search for metastasis should particularly include the regional lymphatic reservoir, a chest x-ray for pulmonary metastasis, a skeletal x-ray of any area of bone tenderness or pain, and a neurologic examination including particularly a funduscopic study. Any hepatic enlargement would be very suggestive of metastasis, and the urine should be examined for the presence of melanin.

*Clinical Course.* Radical surgical extirpation is the only effective treatment for malignant melanomas. The effectiveness of excisional surgery will depend upon the local pathology and the biologic activity of the tumor, that is, the primary site of the tumor and whether or not lymphatic or vascular metastasis has occurred or can be recognized to have occurred. Malignant melanomas show wide degrees of biologic activity, many running a fulminating course with the patient dying of widespread metastasis within a few months of the onset of symptoms or signs, and others showing a very low degree of activity, remaining localized or quiescent for years. Cases have been reported of cutaneous metastasis developing 20 years or more after

masses of muscle tissue, making the diagnosis difficult.

*Diagnosis.* The only diagnostic procedure of any significant benefit is biopsy and histologic study of the specimen. Aspiration biopsy may be used in a superficial mass if one has access to good cytologic pathology; however, an incisional biopsy with minimal handling of the tissue is usually the preferred method. Rarely, in the very small cutaneous tumors, an excisional biopsy with adequate tissue margins all around the tumor may be possible and thus biopsy and adequate therapy are performed simultaneously. Some features discernible on gross examination of the mass may suggest the diagnosis of fibrosarcoma and thus tend to differentiate it from the other "soft-part sarcomas"; however, since biopsy is the only absolute method of establishing the diagnosis in any of the "soft-parts sarcomas," those very inexact features lose most of their clinical significance. These tumors are slow to metastasize; however, they may do so by the blood stream to any part of the body, the lungs being the most frequent site of spread. This has occurred in about 25 per cent of all reported cases. The lymph nodes are involved in only about 10 per cent of the cases; however, in the terminal stages every organ system and tissue of the body may be involved. The local recurrence rate is extremely high. Every reported series of any magnitude has reported at least a 50 per cent local recurrence rate, and a 60 to 70 per cent local recurrence rate has been reported. This reflects primarily the fact that inadequate local surgical treatment has been carried out.

*Treatment.* Wide and deep en-bloc excision of the tumor with a 6 to 8 cm. margin of surrounding tissue is the procedure of choice whenever that is technically possible, and this offers a 5-year cure rate of between 40 and 60 per cent. If this plan can be carried out without sacrifice of vital vascular or nerve structures, it offers the best prognosis with the least disability. It must be stressed that this type of excision should never be considered an office procedure and should always be done in a hospital with the necessary ancillary services of anesthesia and pathology. Amputation is reserved for those patients in whom there is still a chance for cure although radical en-bloc excision is not technically feasible. This plan does not give a higher cure rate than is found following wide local excision; nonetheless, it offers a chance for cure while accepting a greater degree of morbidity and disability. Various forms of irradiation have been used successfully to give palliation in those patients in whom a curative procedure cannot be carried out. Although these tumors generally fall into the so-called "radio-resistant" group, significant palliation may be achieved by the use of x-ray, radium implants or chemical agents such as nitrogen mustard. Chemical perfusion of an extremity containing "soft-parts sarcoma" with nitrogen mustard and other alkylating agents using extracorporeal circulation to isolate the extremity temporarily and thus preventing bone marrow suppression is under extensive clinical investigation. The method shows some definite promise, but its use is too recent for definitive evaluation. Prophylactic regional node dissection is generally not felt to be necessary in the treatment of these tumors; however, in those tumors which arise immediately adjacent to the groin or axilla, the nodes may be removed with the en-bloc removal of the tumor. Of course, in those cases in which the regional nodes are clinically involved without evidence of distant metastasis, radical node dissection is definitely recommended. If there is local control of the tumor and the patient should develop x-ray evidence of a solitary metastasis to a pulmonary lobe, the surgeon should have no hesitancy in recommending that pulmonary resection be carried out. There are several well authenticated reports of long-time survival following such therapy.

Since this tumor has generally been shown to possess a low degree of biologic activity, early wide surgical excision should be expected to lead to a considerable improvement over the cur-

that widely varying degrees of anaplasia are present from one section to the other, with one section showing good cellular and stromal differentiation and few mitoses—and thus compatible with a very low grade malignancy—and yet another section from the same tumor showing such poor differentiation and such pleomorphic nuclei that a highly malignant tumor is suggested. These factors make it extremely difficult to chart the natural history of any specific tumor falling into the "soft-parts sarcoma" group.

*Etiology.* There is little significant evidence to show that there is any real sex or racial preponderance of this tumor. It has been reported in all age groups; however, all reports have definitely indicated that the greatest incidence of the tumor occurs in the third and fourth decades of life. Fibrosarcomas usually develop spontaneously; however, there are sufficient reports of their having arisen in previously damaged tissue to indicate that physical or chemical trauma may play a part in some cases. In one series an 11 per cent incidence of the tumors arising in previously damaged tissues was reported. Sarcomas have been found arising in areas of old leg ulcers, old draining sinuses and in areas of previous heavy irradiation or chemical trauma.

*Pathology.* The great majority of fibrosarcomas occur on the extremities, between 50 and 60 per cent of the reported cases occurring in the lower extremities, 20 to 30 per cent occurring in the upper extremities, and most of the others occurring on the head, neck and trunk. However, these tumors may actually occur in any part of the body where there is mesenchymal tissue present, and they have been reported as arising in the lungs, mediastinum, retroperitoneal tissues, liver, kidney, breast, central nervous system, gastrointestinal tract, etc.

These tumors usually originate as small firm, painless nodules which may grow slowly for long periods of time and thus reach a large size before the patient becomes concerned. They may arise from intermuscular septa or, more commonly, in subcutaneous fascia or in the skin itself. The tumor tends to compress tissue around it as it grows and thus a pseudocapsule is formed from which the tumor can frequently be easily shelled out; however, this is a characteristic that accounts for the very high percentage of local recurrences after limited excision of the tumor, for when this technique is used there are invariably fasciculae of tumor tissue that have extended beyond the pseudocapsule and are thus left behind to form the nidus for recurrence. In the early stages the tumor is rounded, smooth, firm and with a greyish pink to yellow color on cut sections. However, the subcutaneous and cutaneous sarcomas may become quite bulky and ulcerated, resulting in bleeding, foul, infected and fungating masses.



*Figure 98.* Photograph of patient with sarcoma of groin.

*Clinical Manifestations.* A painless, slowly growing mass is by far the most characteristic finding in a case of fibrosarcoma (Fig. 98). In one large series 85 per cent of the cases presented with a mass as the chief complaint. The mass not infrequently reaches a very large size before definitive diagnosis is made. Rarely the mass may be painful and, as such, suggests a poor prognosis, for this usually means that there has been actual nerve invasion by the tumor and thus the hope for cure is greatly diminished. Even more rarely the patient may present himself with a well localized pain and no palpable mass, and thus a deeply seated sarcoma may be hidden by

# Tumors (Continued)

## THE DIFFERENTIAL DIAGNOSIS OF TUMORS OF THE NECK

*By H. Reichard Kahle*

### GENERAL CONSIDERATIONS

Perhaps the most important single thing to bear in mind in examining a patient with a mass in the neck is that, although it is perfectly possible that the tumor in question is an entirely local process, it is also possible that it is either a regional manifestation of a lesion originating in a distant organ or a part of a systemic disease. This generalization is true whether the mass is benign or malignant.

No classification of tumors of the neck and no method of approach to them are entirely satisfactory. A practical plan is to consider them according to the regions in which they appear. Lahey[1] recommended discussing them as midline or lateral, and as single or multiple. This is an over-simplification. Wolfer's[2] recommendation that they be discussed according to the following anatomic regions (Fig. 99) is considerably better:

1. *The midline and the area adjacent to it* extend from the symphysis of the mandible to the suprasternal notch. In this region are the thyroid and parathyroid glands, embryonic thyroid rests, larynx, trachea, esophagus and submental lymph nodes. This area also contains the upper portion of an enlarged thymus gland.

2. *The submaxillary area* lies immediately below the ramus of the jaw and extends from the midline to the angle of the jaw. It contains the submaxillary salivary gland and the submaxillary lymph nodes. Any process extending downward from its origin in the sublingual salivary gland also occurs in this area.

3. *The parotid area* lies above a line extending from the angle of the jaw posteriorly to the scalp line and includes the area about and below the lobe of the ear. It contains the parotid salivary gland and the parotid and postauricular lymph nodes.

4. *The supraclavicular area* lies immediately above the clavicle and extends from the attachment of the sternocleidomastoid muscle to the outer third of the clavicle. It contains the supraclavicular lymph nodes and any lesion that may originate in, and extend upward from the region of large vessels beneath or below the clavicle.

5. *The lateral areas* on each side are limited medially by the midline area, superiorly by the submaxillary and parotid areas, inferiorly by the supraclavicular area and posteriorly by the anterior border of the trapezius muscle. These areas are divided into anterior and posterior triangles by the sternocleidomastoid muscle. They contain the carotid artery, the jugular vein, the carotid

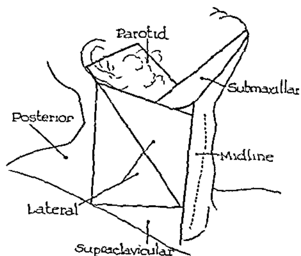



*Figure 99.* Anatomic regions of the neck.

rently reported 5-year control rate of 40 to 60 per cent. However, as long as the removal of these small tumors is approached as a minor surgical procedure, the presently reported local recurrence rate of better than 50 per cent will continue. Surgical therapy of these lesions should, therefore, always be a hospital procedure under appropriate spinal or general anesthesia.

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termined whether lymphadenopathy is present in other regions and whether the spleen or the liver is enlarged. Local appearances may be extremely deceitful. The acute inflammatory changes in the skin and soft tissues overlying an aneurysm have more than once lured the unwary into disastrous incision of a mass in the neck when a more deliberate course would have permitted a correct diagnosis and avoided the disaster.

Indicated laboratory studies usually include roentgenologic examination. This, however, should not be undertaken until after the clinical examination is completed. Biopsy is often necessary, but should not be performed until the case is properly worked up from all other aspects. Histologic examination sometimes produces entirely unexpected results.

### TECHNIQUE OF EXAMINATION

The local examination begins with the patient seated, in a good light, with the clothing dropped below the armpits. The patient must be relaxed, and time must be taken to reassure him if he is tense and nervous The light is moved as necessary to permit a searching view of all areas of the neck. Inspection permits the examiner to observe the contour of the neck, the color of the skin and the presence of visible blood vessels and masses. The mobility of the neck is then tested by having the patient move it forward, backward, laterally and in a rotary motion. At this time it is possible to determine whether the mass changes in size or contour as the position of the neck is changed. The patient is asked to swallow, to determine the relation of the mass to underlying structures, and is given a sip of water if he cannot swallow without it.

Some physicians prefer to continue the examination sitting in front of the patient. A more efficient method is to stand behind him. The finger tips of the examiner can then adapt themselves to the contour of the neck and both sides can be palpated simultaneously. The thyroid gland and masses within the thyroid are best examined from in front because the lateral thyroid lobes are located deep to the sternocleidomastoid muscles. By means of the thumb of the left hand the larynx is displaced to the patient's left, and with the thumb of the right hand anterior and the fingers posterior to the left sternocleidomastoid muscle, the entire outline of the left lateral thyroid lobe can be delineated and palpated (Fig. 101). To examine the right lateral lobe the procedure is reversed.

The various regions of the neck are examined systematically, according to the scheme outlined earlier. Most of the information useful in diagnosis is secured by palpation, but auscultation is employed as indicated.

Normal findings must not be mistaken

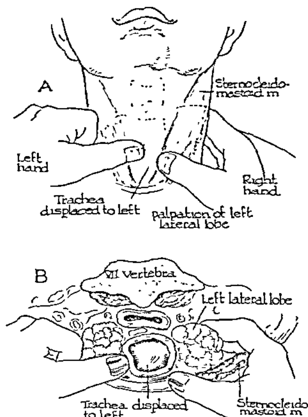



*Figure 101.* Method of palpating lateral lobes of the thyroid. *A*, With the examiner standing in front of the patient, the thumb of one hand *displaces* the trachea to the opposite side. The fingers of the examining hand are placed behind the sternocleidomastoid and the thumb in front. This permits the examiner to palpate the lateral lobe of the thyroid satisfactorily *B*, *Cross section* showing method of examining lateral lobe of thyroid Thumb of the left hand is displacing the trachea to the left The fingers of the right hand are behind the sternocleidomastoid and the thumb in front, permitting examination of the entire lateral lobe

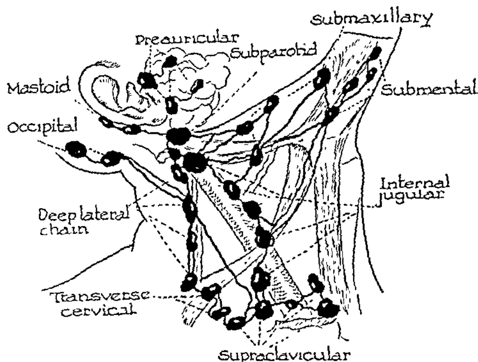



*Figure 100* Lymph drainage of the neck.

body and the cervical lymph nodes. Since the sternocleidomastoid muscle crosses the carotid artery, the jugular vein and the chain of cervical lymph nodes, any process involving the deep cervical lymph nodes may lie anterior to, posterior to, or beneath this muscle.

6. *The posterior area* occupies the posterior aspect of the neck, between the two posterior triangles of the lateral areas It is occupied only by bulky muscles, occasional lymph nodes and the skin and subcutaneous tissue. It contains no specialized anatomic structures Enlarged nodes, although usually indicative of a systemic infection, may occasionally be a clue to an otherwise unrecognized melanoma or infection of the scalp.

Mere listing of the anatomic areas of the neck and the structures they contain gives some indication of the confusion which may be encountered in the diagnosis of masses in the neck. The classification just listed is systematic and logical, but it is, of course, not quite as simple as it appears. A process originating in a structure in one area may cross the anatomic boundary lines of an adjacent area and its point of origin may sometimes be in doubt.

Detailed knowledge of the regional anatomy of the neck is obviously essential for the differential diagnosis of masses in the neck. In addition to thorough familiarity with the anatomic areas and the structures they contain, it is necessary to understand the lymphatic drainage of the neck (Fig. 100), since its direction in a particular area often explains the mode of development of the masses under consideration.

***Routine of Investigation.*** The diagnosis of a mass in the neck should begin with a complete history, including such details as the age, course of development of the mass (mode of onset, duration, rate of development), possible origin (trauma, infection), symptoms, systemic reaction (temperature, pulse), association with other diseases or conditions, and other details which would be included in any properly taken history. In these days of antibiotic therapy inquiry should also be made as to previous treatment and its effect upon the local condition.

The local examination should be preceded by a general physical examination. The order is deliberate. No graver mistake can be made than to assume that even the most obvious of masses is entirely local. It is essential to identify or eliminate pathologic processes elsewhere in the body before drawing conclusions about a mass in the neck. It must be de-

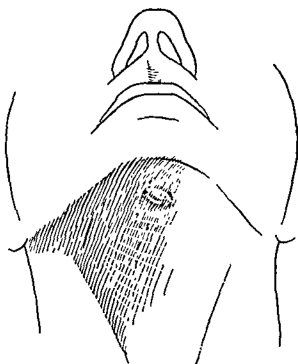


*Figure 102.* Submental adenitis suggestive of infection or malignant process of anterior floor of mouth.

tongue or the floor of the mouth. If it has been present only a few days and is tender on palpation, it is probably only an inflamed lymph node. If it is associated with a chronic lesion in one of these locations, it is likely to be a metastatic malignant lesion, even if the primary lesion has not yet been diagnosed. In older persons, secondary carcinoma should be suspected until it is excluded. In some cases in which there is a primary lesion in the lower lip, tip of the tongue or floor of the mouth, the nodule may be merely an inflamed lymph node present in association with the primary malignant process but not metastatic. An inflamed lymph node, whatever its origin, may go on to infection or abscess formation.

*Sinus.* Although the preferred location for draining sinuses or fistulas in the neck is the anterior border of the sternocleidomastoid muscle, the area inferior to the mandibular border or the midline above the thyroid cartilage, the location and findings depend upon the underlying pathologic process. The most frequent causes are tuberculous lymphadenitis, actinomycosis, osteomyelitis of the jaw and branchial or thyroglossal remnants. The differential diagnosis will be discussed under these various headings.

*Thyroid Disease.* Masses in the midline or immediately adjacent to it are most often of thyroid origin. The thyroid gland originates in the midline, from the foramen cecum at the base of the tongue, and descends into its fetal position through the neck. Because of its attachment to the base of the tongue, the hyoid bone or the thyroid cartilage, a mass arising in the thyroid gland or its vestigial structures will move on deglutition.

The special varieties of thyroid disease are as follows:

*Parenchymatous Goiter.* A parenchymatous goiter is firm, elastic, smooth, usually bilateral, and so extensive that the neck has a full appearance. It varies in size and consistency and it may disappear spontaneously. The patient may have mildly toxic symptoms, which respond to iodine therapy. This type of goiter is particularly likely to appear in women, during adolescence and pregnancy.

*Colloid Goiter.* A colloid goiter is often very large and is usually lobulated. Projections extend down behind the sternum or over it, or laterally beneath the sternocleidomastoid muscles. Lobulations may be soft and fluctuant or firm and elastic, but they are always smooth and rounded. This type of goiter, which tends to appear in middle life, may be preceded by the parenchymatous type. Pressure on the trachea or esophagus may cause respiratory embarrassment or dysphagia, and pressure on the recurrent laryngeal nerve may cause hoarseness or aphonia. If the goiter begins early in life, cretinoid manifestations may occur.

*Toxic Goiter.* (Fig. 103). A toxic goiter may be bilaterally enlarged or may be nonpalpable. It is firm and tense, and a murmur is often heard over it. The patient may complain that the neck feels full. Symptoms and signs are characteristic. They include an increased pulse rate, a decrease in weight in spite of an excessive appetite, mental instability, excitability, tremor, tachycardia, varying degrees of exophthalmos, other

for abnormal. Thus the lateral horns of the hyoid bone, which can be palpated above the larynx, are not abnormal masses. They are present normally. The crepitation or click sometimes felt, and occasionally heard, when the larynx is manipulated laterally is also normal. If it is absent, in fact, some abnormal process such as carcinoma of the larynx, with invasion and fixation, should be suspected.

A mass found in the course of the local examination demands further detailed study. Its location, shape, size, consistency, regularity, lobulation and other physical properties must be determined. It must be determined whether it is solitary or multiple, unilateral or bilateral, discrete or fused with other masses, tender, movable, elastic or fluctuant It must also be determined whether it is fixed to the mandible, trachea, cervical spine or adjacent soft structures. The characteristics of the overlying skin, including discoloration, edema and infiltration, must be investigated. All findings must be recorded accurately and in detail, for comparison with findings at later examinations.

Pulsations must be investigated, to determine whether they are in underlying blood vessels or in the mass itself. A pulsating mass, especially if it is in the supraclavicular area or in the vicinity of the carotid arteries, should always be auscultated. By this means the murmur of an aneurysm or the increased vascularity of a hyperplastic thyroid can be detected.

A smooth, firmly elastic, pulsating mass in the supraclavicular area, which extends upward from behind the clavicle is probably an aneurysm of the subclavian artery. If the pulsation is detected after trauma, such as a gunshot or stab wound in the area, the mass should be considered a traumatic aneurysm until the contrary is proved. A nontraumatic pulsating mass, extending upward from behind the clavicle on either side, introduces the possibility of an aneurysm of syphilitic origin.

The expansile pulsation of an aneurysm must be differentiated from the pulsation transmitted through a tumor by an underlying artery. A murmur may be heard over an aneurysm. The tracheal tug, which is noted when the trachea or the cricoid cartilage is fixed by the finger, with slight upward pressure, usually indicates an aneurysm of the aortic arch. The explanation of the tug is the pulsation of the aneurysmal sac which is adherent to the trachea or the left bronchus. Much less often a tracheal tug is present in simple dilatation of the aorta or cardiac hypertrophy. Episternal pulsation is usually indicative of an aneurysm of the aortic arch, though it may also be present in neurocirculatory asthenia or when anomalous blood vessels occur in the mediastinum. The true expansile character of an aneurysm is evident on fluoroscopy, which is usually conclusive.

Occasionally a dilated jugular bulb, usually on the left side and located immediately above the clavicle, is mistaken for a neoplasm or aneurysm. It is, however, of no significance except for its prominent appearance. Aside from this exception, dilated veins in the neck are not likely to be mistaken for a tumor. Whatever the particular cause, the general cause is obstruction of the return blood flow. Paroxysmal dilatation sometimes occurs in episodes of bronchial asthma. Unilateral engorgement may be caused by a mediastinal tumor, a large aneurysm of the arch of the aorta, or a substernal thyroid. Bilateral engorgement is usually an indication of cardiac disease, often with congestive failure. Less often it indicates mediastinal disease. Percussion may reveal the particular process responsible, but diagnosis most often is made by fluoroscopy and roentgenologic studies.

### MASSES IN THE MIDLINE

***Enlarged Lymph Node* (*Fig. 102*).** A nodule felt in the midline just below the tip of the chin is usually an inflamed lymph node. It is best demonstrated by pressing it upward against the jaw or the floor of the mouth. A nodule in this position is always secondary to a primary process in the lower lip, the tip of the

mon. Nodules in the thyroid may be true neoplasms, adenomas, or nodular masses in a thyroid in which involutional changes have occurred usually after a period of hyperactivity of the gland.

A nodular goiter may also take the form of an irregular, nodular mass, made up of both hyperplasia and colloid formation. Malignant change is much more likely in a true adenoma than in the nodule resulting from involutional change in the thyroid. The nodules, which are circumscribed and firmer than the remainder of the gland, may be very small or as large as 2 inches or more in diameter. Hemorrhage into one of the adenomas (as into the single adenoma) may cause sudden localized enlargement and pressure symptoms.

The fact that a certain proportion of thyroid adenomas and nodular goiters become malignant makes the differential diagnosis of great importance. Cope[3] called attention to the "Delphian" node as a valuable early diagnostic sign of carcinoma of the thyroid gland. This node lies just above the thyroid isthmus in or near the midline (Fig. 106) and is normally not palpable. When involved with metastasis or inflammation, however, it is more easily palpated than most cervical nodes because it is covered only with skin and superficial fascia, the platysma being absent, and because it lies upon the flat surface of the middle cricothyroid ligament or the cricoid cartilage. Care must be taken to distinguish it from the pyramidal lobe of the thyroid. It must also be borne in mind that, although usually indicative of carcinoma, a palpable "Delphian" node may be found in thyroiditis, particularly of the Hashimoto type, and in other inflammatory conditions. Histologic examination is the only sure method. The danger of malignant change is variously reported, but is usually thought to be more frequent in single nodules than in the multiple type of nodular goiter. The younger the patient with a solitary thyroid nodule, the greater is the possibility that the nodule is neoplastic. In 51 cases of carcinoma of the thyroid observed over a seven-year period, in which 529 nontoxic nodular goiters were observed, Cerise and associates[4] found the incidence of malignant lesion to be 19.8 per cent in glands with

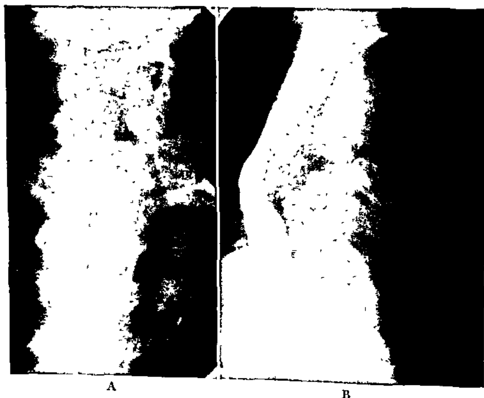



*Figure 105.* Roentgenogram showing displacement of (*A*) trachea and (*B*) esophagus by goiter at thoracic inlet.



*Figure 103.* Diffuse toxic goiter.



*Figure 104.* Nodular nontoxic goiter.

eye signs and an elevation of the basal metabolic rate. Cardiac disease is frequently associated with advanced stages of the disease. Atypical manifestations may confuse the examiner.

*Nodular Goiter.* Nodular goiter may be manifested by a smooth, firm, well circumscribed, single nodule in any area of the thyroid gland, or by multiple nodules (Fig. 104). They sometimes extend into the thoracic inlet where they give rise to pressure symptoms if they are of any size (Fig. 105). If located in the isthmus, pressure symptoms are com-



*Figure 107.* Carcinoma of the thyroid with metastasis to the cervical lymph nodes.

which is an infrequent process, may occur in the course of an acute infectious disease or develop secondary to an infection in the area of the thyroid gland. Occasionally the process is primary. The symptoms are those of infection anywhere else in the body and are both local and general. Usually the gland enlarges suddenly. It may give rise to pressure symptoms and may go on to abscess formation. Radioactive iodine uptake studies are of inestimable value in the diagnosis of both acute and chronic thyroiditis.

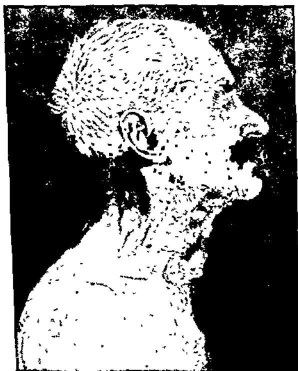


*Figure 108.* Carcinoma of the thyroid with metastasis to the deep cervical nodes.

*Chronic Thyroiditis.* Chronic thyroiditis is a slow, progressive enlargement of the thyroid gland, associated with episodes of tenderness and slight pain. The enlargement may be followed by a decrease in size, and the gland then becomes diffusely hard and stony because of fibrosis (Riedel's disease). Areas of stony-hard calcification may suggest carcinoma.

*Struma Lymphomatosis.* In struma lymphomatosis (Hashimoto's disease) the thyroid gland is small, hard and nodular and often has the physical characteristics of chronic fibrous thyroiditis. The normal acini become atrophic and are displaced by diffuse lymphoid infiltration.

*Calcification.* Calcification of the thyroid gland may be a sequel of chronic thyroiditis or toxic goiter and may be localized or may involve almost the whole gland. In the diffuse variety there has usually been a preceding low-grade chronic thyroiditis. A localized area of calcification often follows hemorrhage into the gland. Pressure symptoms are frequent. Roentgenologic examination establishes the diagnosis (Fig. 109).

*Carcinoma of Thyroid.* Carcinoma of the thyroid may appear in a previously normal gland or in a gland that has been the site of adenomatous or other changes. Physically it is manifested as a hard mass fixed to the gland tissue. It tends to infiltrate and to increase in size without remissions. Distant metastases, including metastases to the bone, are frequent. The

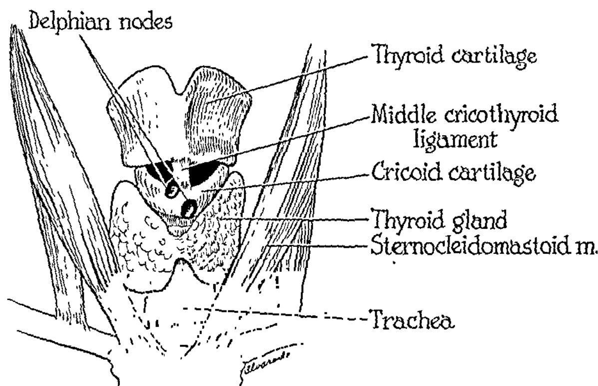



*Figure 106.* Diagrammatic representation of possible locations of "Delphian" node.

single nodules and 12.8 per cent in glands with multiple nodules

*Congenital Goiter.* A congenital goiter, present at birth, is likely to be very large and may contain parenchymatous or cystic areas; colloid is scanty or absent. This type of goiter is particularly frequent in children of goiter-bearing parents. It is also observed in mothers who have been taking propylthiouracil. A fetal adenoma may also be present at birth. It is smooth, well circumscribed and elastic. As a rule, it grows for varying periods of time, then becomes stationary.

*Lingual Thyroid.* Lingual goiter is extremely unusual. Ward and his associates,[5] in a review of the literature in 1954, found "well over 200" reported, but found only three in approximately 800,000 admissions to the Johns Hopkins Hospital. Only three were observed in 25,000 goiters treated at the Lahey Clinic up to 1947 [1]

This type of goiter may develop if the thyroid gland fails to complete its normal descent into the neck from its point of embryonic origin at the base of the tongue in the foramen cecum. If the abnormally located thyroid tissue becomes the site of a goiter, it may project into the pharynx (supralingual), develop within the substance of the posterior third of the tongue (intralingual) or project from the tongue just above the hyoid bone (sublingual). An adenoma may develop in a lingual thyroid, and so, presumably, may any of the other pathologic processes which occur in the thyroid gland in its normal location. Diagnosis is made on the basis of the median position of the mass, its increase in size, and the absence of the gland from its normal location. The supralingual type of goiter must be differentiated from a tumor of the tongue or the pharynx, the intralingual type from the same tumors and from lymphangioma, and the infralingual type from a thyroglossal cyst Radioiodine tracer studies now provide a highly accurate method of diagnosis.

Whether or not a lingual thyroid is particularly subject to malignant change is not yet established. Since most of them are removed early in life, data are lacking. All reported cases of malignant change, according to Ward and associates, have occurred in middle life and chiefly in males. The possibility of malignant change obviously makes prompt diagnosis a matter of great importance.

*Acute Thyroiditis.* Acute thyroiditis,

the irreversible stage if studies of blood calcium were more frequently a part of routine physical and chemical examinations. The Sulkowitch test, a turbidity test of the urine, is a simple means of detecting excessive calcium excretion.

***Persistent Thymus in Children.*** A mass apparently originating behind the sternum is likely to be a persistent thymus. It is usually seen in the newborn or in very early infancy. Symptoms include loud, wheezy breathing, laryngeal stridor or laryngeal spasm with cyanosis and other manifestations.

The differential diagnosis is by percussion and roentgenograms. It includes teratoma. This tumor extends upward through the thoracic outlet to appear in

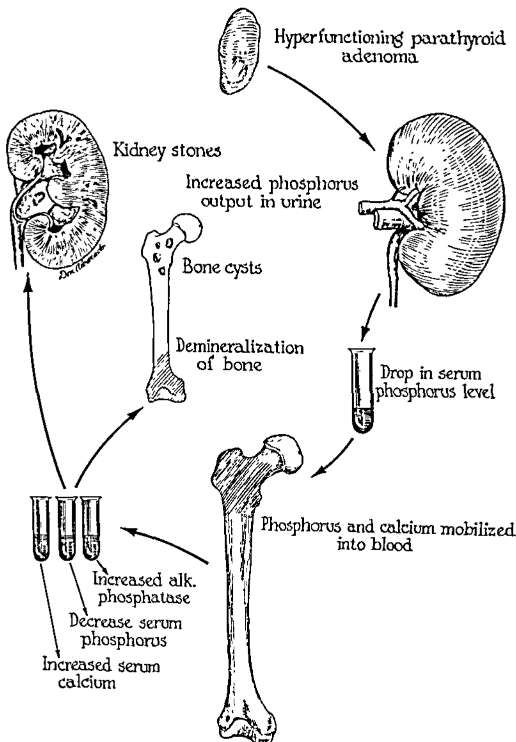



*Figure 110.* [illegible] ...ing parathyroid



*Figure 109* Roentgenogram showing calcification in a large nontoxic goiter

infiltrative type may cause paralysis of the recurrent laryngeal nerve or Horner's syndrome. Involvement of the recurrent laryngeal nerve is conclusive evidence of the diagnosis, but does not occur until *the disease is advanced* (Figs. 107 and 108). Frequently in papillary carcinoma of the thyroid, the first manifestation of the lesion is the appearance of lymph node metastases in the deep cervical nodes. These previously were erroneously diagnosed as lateral aberrant thyroids and although the thyroid lesion may be so small that *it is not palpable, it can* be demonstrated in the thyroid, usually the homolateral lobe, on microscopic examination.

It is difficult clinically to differentiate carcinoma of the thyroid from adenomatous or calcified thyroid tissue. Numerous points of differentiation have been suggested, but none of them are conclusive at a time when therapy is still curative. The only safe policy is prompt surgical investigation, with histologic examination.

***Parathyroid Tumor.*** A parathyroid tumor may appear as a discrete, nonhyperfunctioning adenoma in which cystic degeneration may occur, as a hyperfunctioning adenoma, or as a localized malignant tumor.

Tumors of the parathyroid glands are most often found in the normal location of these glands, which is close to the upper or lower poles of the thyroid gland. They may, however, appear in every conceivable location near or within the glands, completely detached from them, and even in the anterior mediastinum.

Most parathyroid tumors are not visible on inspection and are not always *demonstrable even on careful palpation.* For this reason, a nonfunctioning adenoma, even after cystic degeneration has occurred, is frequently only an accidental finding at an operation for thyroid disease or at necropsy. Even hyperfunctioning adenomas, the most frequent of these tumors, may not be detectable on *physical examination. Malignant tumors* are usually nonfunctioning and the diagnosis must be made by histologic examination. A palpable tumor is usually, like a thyroid adenoma, small, firm and elastic, and it moves with the thyroid gland.

Attention is most often called to a *parathyroid tumor by the symptoms it* causes, and the symptoms, unfortunately, most often are indicative of advanced disease. They are chiefly referred to the muscles and bones. They include pain in the back and extremities, changes in the gait and muscular weakness. Later, pathologic fractures occur. The rounded *back which indicates collapse of a* vertebral body or bodies is indicative of late disease. Decalcification of the bony skeleton may be of all degrees. Sometimes it is so complete that only the outlines of the bones are evident on the roentgenograms. Associated with these changes are elevation of the blood calcium, elevation of the blood alkaline phosphatase level and decrease of the blood phosphorus (Fig. 110). The diagnosis should always be considered in a patient who has renal calculi or whose urograms show intrarenal calcification. As Lahey pointed out, the disease would be less often seen in

*Mixed Tumor.* About 10 per cent of all mixed tumors occur in the submaxillary gland. The mass grows slowly over a period of years, is firm or hard on palpation, but is neither painful nor tender. Diagnosis is made by biopsy. It is essential that complete removal be accomplished, since recurrent tumors are highly malignant.

*Metastatic Carcinoma.* In adults, even young adults, metastatic carcinoma should always be considered as a diagnostic possibility if a mass appears in the submaxillary area, grows gradually and eventually becomes fixed and stony hard, though it is neither painful nor tender in its incipiency. The point of origin is usually a primary malignant tumor in the lip, alveolar process, lateral margin of the tongue or buccal surface of the cheek. Any lesion in these areas, no matter how small, must be removed and examined microscopically in order that a diagnosis of malignant disease can be either confirmed or excluded. It is characteristic of primary malignant tumors in this area that they may become active several years after a cure seems to have been effected by excision.

### MASSES IN THE PAROTID AREA

Masses in the parotid area will be easier to diagnose if one remembers their tendency to displace the pinna outward.

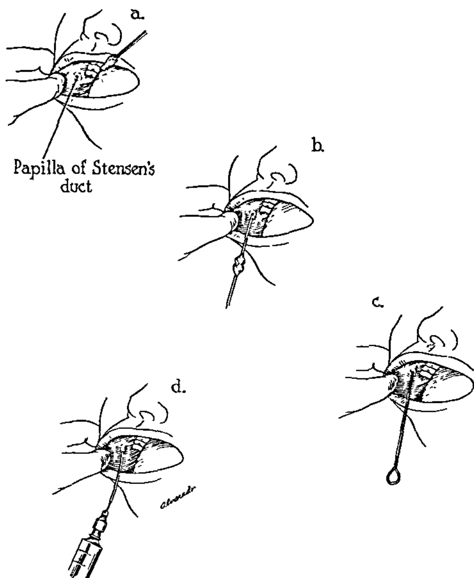



*Figure 112.* Technique of sialography. (*a*) Papilla of Stensen's duct is identified opposite the second molar tooth and anesthetized with a 10 per cent solution of cocaine. (*b*) The duct is probed with a lacrimal probe. (*c*) Polyethylene catheter of appropriate size is introduced by means of a wire stylet. (*d*) Duct is injected with a 50 per cent solution of Hypaque.

the neck near the midline. It grows rapidly and may give rise to respiratory symptoms from pressure on the trachea.

## MASSES IN THE SUBMAXILLARY AREA

Masses in the submaxillary area may be inflammatory, obstructive or neoplastic. They arise from processes in the submaxillary and sublingual salivary glands, as the result of inflammatory disease, calculi and tumors.

*Inflammatory Processes.* A mass that appears rather suddenly and is tender to pressure is likely to be an acute lymphadenopathy (Fig. 111), usually secondary to some infectious process within the mouth The patient is seldom seen early enough for the lymph nodes to be palpated individually. If the process in the mouth is not arrested, other nodes in the cervical chain will become involved.



*Figure 111.* Submaxillary adenitis.

Inflammatory processes in the submaxillary area include Ludwig's angina, osteomyelitis of the jaw and actinomycosis. Ludwig's angina is not a tumor in the true sense of the term but, because of the brawny swelling in the submaxillary area which occurs with it, it must be considered in the differential diagnosis of masses in the submaxillary area. Pain, chills, fever and toxicity are highly suggestive, but the conclusive evidence is demonstration of the thickening in the floor of the mouth, which is accomplished by outlining it internally with the finger while palpating externally with the other hand. The process is really a cellulitis which begins in the floor of the mouth and extends downward to involve the submaxillary lymph nodes and sometimes the salivary glands. As the disease progresses, the induration may extend downward into the anterior triangle of the lateral cervical space. Abscess formation may occur. Mild cases are hard to differentiate from subacute or chronic infection of the subcutaneous tissues.

Osteomyelitis of the jaw may give rise to a mass that seems to be attached to the mandible and extends upward over it as well as downward in the soft tissues. The primary process is the result of an infection about a tooth or of necrosis after irradiation of the area for malignant disease. Abscess formation is common. The clinical diagnosis is readily confirmed by roentgenograms.

A chronic form of necrosis of the jaw suggests the possibility of actinomycosis. The infection is thought to enter the soft tissues of the neck by way of the mouth, most often through a carious tooth. Although it may appear anywhere in the neck, it is most frequent in the submaxillary area. The mass is almost stony hard as the result of excessive deposition of connective tissue. There are generally multiple draining sinuses. The diagnosis is confirmed by the finding of characteristic sulfur granules in the discharge.

*Obstruction of the Salivary Gland.* Obstruction of the submaxillary gland (Wharton's duct) is manifested by a relatively painless asymptomatic swelling which comes on suddenly, and often dramatically, within a period of minutes. It is caused by blockage of the duct by a calculus. If infection enters the picture, the mass becomes painful and tender and may increase slightly in size from day to day. Characteristically the clinical picture is aggravated by eating, especially sour substances. Diagnosis is made by digital palpation of the stone supplemented by roentgenologic examination.

*Sialography.* Sialography affords an accurate means of studying the ductal system of the parotid gland. Distortion by a stone or tumor may be readily demonstrated.

The technique of sialography is illustrated in Fig. 112. A 10 per cent solution of tetracaine hydrochloride is applied topically to the papilla of Stensen's duct *opposite the second upper molar tooth.* A cannula may be introduced into the duct, but it is better to introduce a sterile polyethylene catheter that fits tightly. The various available sizes permit proper selection. The catheter is connected to a 5 cc. Luer-Lok syringe and a *50 per cent solution of Hypaque is injected.* Ordinarily, from 0.25 to 5 cc. of the solution will suffice. Injection is discontinued when the patient notes a feeling of tightness in the gland. Suitable films are taken and the catheter is withdrawn. Additional pictures are made 2 or 3 minutes later after partial emptying has occurred. Fig. 113 illustrates a normal sialogram.



*Figure 114.* Large, mixed tumor of parotid gland.

*Mixed Tumor.* A mixed tumor of the parotid gland (Fig. 114) is a slow-growing enlargement which occurs over a period of years. For months at a time there may be no evidence at all of growth. The mass, which may be in either the body or the periphery of the gland, is usually firm or hard and is *irregular. In spite of tremendous growth* of some mixed tumors of the parotid there may be no facial nerve weakness (Fig. 115). When, however, facial nerve weakness or paralysis is present, it usually indicates a malignant tumor and direct involvement of the nerve by the neoplastic lesion. Sometimes the tumor grows rapidly, becomes adherent to the skin, and involves the regional lymph nodes. According to Wolfer,[2] a tumor which behaves in this manner is a carcinoma. Recurrence after excision may be long delayed but the secondary growth is usually more malignant.

*Primary Carcinoma.* Primary carcinoma of the parotid gland usually ap-



*Figure 115* Enormous mixed tu paralysis



*Figure 113* Normal sialogram. Sialography may be used as an aid in differential diagnosis of masses in the parotid area by demonstrating obstruction, dilatation, stenosis or distortion of the duct.

This is because the parotid gland lies in a compact compartment and extends upward and anterior to the lobe of the ear as well as below it.

***Parotitis.*** In childhood and early adolescence the most logical diagnostic possibility in a sudden swelling in the parotid area associated with systemic symptoms is mumps. The diagnosis is established if there is difficulty in opening the mouth and if a history of contact can be obtained. Involvement of the opposite side furnishes additional confirmation.

Postoperative parotitis usually begins as a unilateral swelling associated with fever, pain, trismus and malaise in a patient from whom food has been withheld for some time It takes two forms. In the mild form the onset is gradual, the enlargement is moderate, fever is low or moderate, and pain and tenderness are also moderate. The opposite side tends to become involved just as the process on the first side tends to subside. In the fulminating type, the symptoms include fever, chills, rapid swelling and severe pain. Edema of the affected side is extreme and soon becomes hard and brawny. Death may occur in 48 to 72 hours after the onset. The explanation of the symptoms and course is that rapid swelling within a structure confined by dense fascia causes the original pain and toxicity, while impairment of the arterial blood supply as the result of pressure causes necrosis, with relief of pain but not of the toxic symptoms.

***Aberrant Salivary Gland Tissue.*** Aberrant salivary gland tissue may appear in the periphery of the parotid or at other locations in the form of small, firm, freely movable, nontender masses which do not change in size unless they become the site of neoplastic disease.

***Calculus of Stensen's Duct.*** Obstruction of Stensen's duct caused by a calculus is manifested as a more or less painless swelling of the parotid gland which increases in size during a meal and then resumes its ordinary size; the saliva distends the gland during mastication, when it is most abundant, and is present in only small amounts after the food has been ingested. If infection supervenes, acute exacerbations with extensive swelling, pain, fever and edema of the overlying skin may occur and may go on to abscess formation. If infection does not occur, the process may last for years, terminating in residual enlargement with fibrosis.

empties into the jugular vein at its junction with the subclavian vein. A node in the same location may also be the only gross evidence of carcinoma of the lung. In this disease, however, the palpably enlarged supraclavicular nodes may be multiple.

It should be emphasized that a true Virchow sentinel node is always on the left side. A metastatic nodule or nodules may appear in the supraclavicular area on the right but they are of different origin.

*Pancoast's Tumor.* Pancoast's tumor (Fig. 117), formerly called a primary pulmonary sulcus tumor, is now regarded as a carcinoma of the lung in a special position, the pulmonary apex. It presents as a hard, rather fixed tumor which extends upward from behind the clavicle in the supraclavicular region over the apex of the lung. It grows slowly and has little tendency to metastasize but has a decided tendency to invade the ribs and brachial plexus; as a result, pain extends down the arm. Because the cervical sympathetic chain passes through the area in which Pancoast's tumor is located, the tumor may be associated with the group of symptoms and signs known as Horner's syndrome (depression of the eyeball, ptosis of the upper eyelid, slight elevation of the lower lid, constriction of the pupil, narrowing of the palpebral fissure, and anhidrosis).

#### MASSES IN THE LATERAL AREA

*Branchial Cyst.* Branchial cysts are discussed in Chapter 7, page 96.

*Cystic Hygroma.* The diagnosis and differential diagnosis of cystic hygroma (Fig. 308, p. 414) are fully discussed under the heading of lymph tumors. The possibility should be suspected in any mass in the lateral area of the neck which is present at birth, has a doughy or tense cystic consistency, and tends to grow rapidly.

*Hematoma.* A hematoma may appear in any area of the neck but is particularly frequent in the lateral area because the sternocleidomastoid muscle, which is highly vascular, is readily bruised or otherwise injured. Diagnosis is simple if a history of injury is obtained. If it is not, the origin of the swelling may be perplexing. It usually comes on suddenly, increases in size over a period of days, and is tense and uncomfortable but not painful. After several days more it becomes softer and fluctuant. Blood can be obtained on aspiration. The important consideration in a hematoma is to avoid surgical treatment, which is usually not necessary.

*"Lateral Aberrant Thyroid."* It was once thought that lateral aberrant thyroid tissue arose from lateral thyroid anlagen. It is now known that the anlage of the thyroid is only median and that so-called lateral aberrant thyroid tissue represents metastases from carcinoma of the thyroid. In 49 of 57 such cases studied by Warren and Feldman[6] there was an associated thyroid cancer, which had not been detected in 15 per cent of the cases. In the other eight cases the thyroid gland was not available for examination. Cerise and associates[4] found primary carcinoma in the homolateral lobe of the thyroid in all 9 cases of lateral aberrant thyroid which came to their attention over a 7-year period at the Ochsner Clinic.

"Lateral aberrant thyroid" tumors are uncommon. Lahey[1] observed them only 47 times in more than 25,000 goiters. They may be single or multiple, and unilateral or bilateral. Multiple, whether unilateral or bilateral, are located under the anterior edge of the sternocleidomastoid muscles, in close relation to the internal jugular vein, at the level of, or a little above, the superior thyroid artery (Fig. 118). They appear in younger persons more frequently than does cancer in general. The presenting finding, according to Warren and Feldman,[6] is a swelling or nodule in the neck, and the pretreatment interval averages almost 4 years.

*Diverticulum of the Esophagus.* A diverticulum of the esophagus should be thought of in connection with a mass that appears in an older person, that lies lateral and posterior to the thyroid cartilage, or lower, that is usually on the left, that is not tender or painful, and that

pears during the third or fourth decade of life as a hard, rapidly growing mass, which soon involves the regional lymph nodes. Fixation and erosion of the overlying skin occur early.

MASSES IN THE SUPRACLAVICULAR AREA

*Virchow's Node.* Virchow's sentinel node is a discrete nodule above the left clavicle, beside the attachment of the sternocleidomastoid muscle. It is firm or hard, freely movable unless it is very large, and nontender. It most often is indicative of widespread metastases from carcinoma of an intra-abdominal viscus, usually the stomach. It may be present even when the gastric lesion is small. It is caused by metastatic emboli from the primary lesion which travel by way of the thoracic duct (Fig. 116). This duct

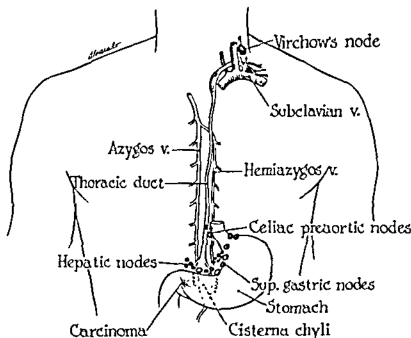



*Figure 116.* Virchow's node Diagrammatic illustration of route by which metastasis from an abdominal malignant tumor may first be manifested clinically by a node in the left subclavian notch.



*Figure 117.* Pancoast's tumor. Roentgenogram illustrating mass in superior sulcus where involvement of cervical sympathetic chain may cause Horner's syndrome



*Figure 120.* Recurrent carotid body tumor.

Opinions differ as to the chances that a carotid body tumor may become malignant. All of Lahey's 18 cases were benign. Birrell[9] regarded the figure of 50 per cent reported by some observers as completely out of proportion and pointed out that the criteria for malignancy applied by various authors vary widely and that definitely atypical cellular growth is rare.

The differential diagnosis of carotid body tumors includes metastatic carcinoma to the jugular lymph nodes, branchial cysts, and aneurysm of the carotid artery.

If the patient has undergone radical neck dissection, the carotid bulb stands out conspicuously and is often erroneously mistaken for a recurrent neoplasm or metastatic node.

### MASSES IN THE POSTERIOR AREA

Tumors of the skin, such as sebaceous cyst and dermoids, are considered on pages 103–108.

*Lipomas are frequent.* They appear as flat, lobulated masses, of a soft, irregular consistency. The overlying skin is normal. Similar tumors may appear elsewhere in the body. All are superficially placed. They may produce neuralgic pain (Dercum's disease, adiposis dolorosa).

A smooth, globular, tense, compressible tumor located in the midline beneath the occiput and present at birth is usually a *meningocele*. It increases in size when the child cries or strains. When it is compressed, slowing of the pulse rate and vomiting, which are symptoms referable to the cerebrum, may be produced.

A meningocele is a sac containing cerebrospinal fluid and is formed by the meninges protruding through a defect in the occipital bone above the foramen magnum. The overlying skin, originally normal, may ulcerate, and infection may lead to perforation and secondary meningitis. Occasionally overlying skin is absent and the mass appears as a fragile, glistening membranous sac. Treatment is a major surgical problem requiring hospitalization.

### MULTIPLE MASSES

Multiple masses in the neck are classified as infectious or hyperplastic, acute or chronic, and primary or secondary neoplastic. The findings depend upon the stage at which the patient is seen. When seen early, the physical findings may be so nearly identical in all of these conditions that differential diagnosis is possible only by microscopic examination.

*Acute Lymphadenopathy.* Multiple masses that appear suddenly in association with fever and other systemic manifestations are of infectious origin. Local




*Figure 118.* Carcinoma of thyroid in a child, with metastasis to cervical lymph node *A*, Frontal view; *B*, lateral view, demonstrating deep cervical node metastasis



*Figure 119.* Roentgenogram showing filling of pulsion pharyngo-esophageal diverticulum, characteristic location extending to the left.

varies in size from day to day or even hour to hour. It increases in size when food is taken and may practically disappear if food is omitted over an extended period. Choking and regurgitation when food is taken are characteristic symptoms. The mass is visible and readily palpated during periods of enlargement. The consistency is doughy and mobility is slight. Roentgenologic study with opaque material is diagnostic (Fig. 119)

***Carotid Body Tumor.*** Carotid body tumors (chemodectomas) are not common. Pettet and associates[7] found 314 cases in the medical literature up to 1953, 19 of these being from the Mayo Clinic. Between 1907 and July 1952, 47 carotid body tumors were observed at this institution.

These nonfunctioning, nonmetastasizing tumors arise from the chromaffin cells located at the carotid bifurcation. The constancy of their origin gives them a constancy of location not characteristic of most tumors in the lateral portion of the neck. Moreover, because of the fixation of the carotid body in the notch of the division of the common carotid into the external and internal carotid arteries, it is possible to move them only transversely (Fig. 120). They cannot be moved vertically. They are deeply located, and, again because of their location, they must enlarge upward and usually inward, toward the pharynx. Pressure symptoms are usually the only symptoms.

In an occasional patient with this type of tumor carotid sinus syncope or vasovagal syncope[8] will develop. The episodes are characterized by sudden dizziness, faintness and, less often, convulsions, associated with a sharp fall in blood pressure and a slow pulse rate. The cause is assumed to be pressure of the tumor upon a sensitive carotid sinus.

tive of grapes. Discrete glands do not break down. Later in the disease the lymph nodes become matted together, especially if secondary infection sets in; at this time they are fixed. The lymphatic involvement becomes generalized and other areas of the body are affected, not only the opposite side of the neck but the axillary and inguinal lymph nodes and the nodes in the mediastinum. The spleen is often enlarged.

As the disease spreads, fever is a prominent symptom. The episodic elevations, often to 105° F. over a period of days, are followed by a decrease over about the same period of time (Pel-Ebstein syndrome). Gastrointestinal hemorrhages are frequent. If fibrous tissue reaction is a prominent feature of the pathologic process, pressure symptoms may arise from pressure on the trachea, esophagus or recurrent laryngeal nerve.

Diagnosis can be made positively only by biopsy, which should not be delayed. Prompt, appropriate treatment may result in long remissions, whereas the untreated disease may be fatal within the year.

The cervical lymphadenopathy of leukemia may be preceded by such symptoms as malaise, fatigue and anorexia. Excessive bleeding after slight trauma is frequent. The initial symptoms and signs may also be acute and may include weakness, pallor, fever and sore throat. Purpuric and ecchymotic lesions of the skin and mucous membranes are common. Tenderness over the sternum, which can be elicited by firm pressure, indicates cellular hyperplasia within the bone marrow.

The disease is characterized by widespread proliferation of leukocytes in the body tissues. In the chronic myelogenous variety splenomegaly is often present, but the lymph node involvement is minimal as compared with the involvement in the chronic lymphatic variety, in which splenomegaly is less pronounced.

*Lymphosarcoma.* There are three varieties of malignant lymphoid tumors which may occur primarily or secondarily in the neck, namely, lymphocytic lymphosarcoma (Fig. 122), in which the cells simulate normal lymphocytes; lymphoblastic sarcoma, in which the cells resemble lymphoblasts of the germinal centers; and giant follicular lymphosarcoma.

Lymphosarcoma may occur at any age. It is slightly more frequent in men. In the early stages the involvement of the cervical lymph nodes is nonspecific (Fig. 123). Growth, however, is rapid, the lymph nodes fusing and softening in relation to the rapidity of the process.



*Figure 122.* Lymphoma of adult lymphocytic type in posterior cervical triangle.

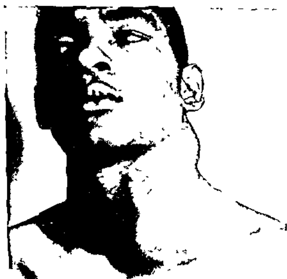


*Figure 123.* Lymphosarcoma involving the deep cervical nodes.

conditions usually give rise to unilateral lymph node involvement. Bilateral involvement is likely to be of systemic origin. The deep cervical chain is most often involved, but other areas in the neck may also be affected, as may the axillary and inguinal regions Early in the disease the nodes are discrete, firm, and freely movable. There are no abnormalities of the skin The masses may increase in size rapidly and become tender. Sometimes they progress to suppuration and a draining sinus results

Acute cervical lymphadenopathy in young children may be present in such diseases as measles, scarlet fever and diphtheria. It tends to subside as the systemic disease subsides, though it may go on to infection and suppuration. It may also be present with Vincent's angina, tonsillar infections, acute infectious hepatitis, brucellosis, acute infectious mononucleosis and tularemia. The enlargement is likely to become chronic if it is associated with chronically infected tonsils.

*Chronic Lymphadenopathy.* Chronic lymphadenopathy begins insidiously and progresses gradually. Often it originates in a single area and then spreads to other areas. In the beginning the lymph nodes are discrete, firm, smooth, elastic, freely movable and nontender. Later they tend to become fused. The differential diagnosis includes, in addition to chronic inflammatory conditions, Hodgkin's disease, lymphosarcoma and leukemia. Metastatic malignancy is also a possibility.

Tuberculous cervical lymphadenitis has become increasingly infrequent as government inspection of dairy cattle has progressively eliminated the chief etiologic factor. The site of onset, which is usually insidious, depends upon the point of entrance of the infection. Initial symptoms include malaise, sweats, loss of weight and low grade fever. Physical examination reveals a mass consisting of multiple fused nodes, most often at the mid level of the neck Even after other areas are involved, the original area is likely to remain most deeply involved. Caseation is frequent and roentgenologic



*Figure 121.* Tuberculous cervical lymphadenitis, showing multiple fistulas and considerable scarring

examination may reveal calcification. Rupture of the broken-down mass often occurs; then there is a decrease in size but the residual mass does not disappear and a chronic draining sinus also remains (Fig. 121). Association with pulmonary tuberculosis is so frequent that this possibility should always be investigated, by standard methods. Biopsy is the only certain means of diagnosis in cases in which the lymph nodes remain discrete and do not coalesce.

***Hodgkin's Disease; Leukemia.*** In the early stage of both leukemia and Hodgkin's disease there is nothing specific about the involvement of the cervical lymph nodes which would distinguish these conditions from each other. Both begin with involvement of the lymph nodes, and most often with involvement of the cervical lymph nodes. In Hodgkin's disease the lymph nodes in the posterior lateral triangle or about the bifurcation of the carotid artery are often the first to be involved.

Hodgkin's disease is more common in men than in women and most frequent in the third decade of life. The initial symptoms may be nothing more than slight malaise In the beginning the lymph nodes are painless, firm, discrete, freely movable and nontender. Their appearance and consistency are sugges-

types of lymphosarcoma are almost spectacularly radiosensitive.

*Metastatic Malignancy.* Malignant metastasis to the neck may appear as a single node but this is unusual. As a rule, the involvement is multiple and there is nothing characteristic about it except that the affected nodes are unusually firm. As the process continues, the nodes become matted together and fixed. Sometimes, but not always, they are stony-hard. The involvement may be so extensive that all areas of the affected side are involved. Discoloration of the skin is followed by ulceration and sloughing, and pressure symptoms are common.

This type of lymphadenopathy in the submaxillary or deep cervical regions should arouse suspicion of a primary carcinoma within the mouth, nasopharynx or nose. Huge metastases are sometimes present when the primary tumor is small or inconspicuous. (Figs. 124, 125). Carcinoma of the pharynx is particularly prone to behave in this paradoxical fashion. The site of primary origin may be in the nonkeratinizing, stratified squamous epithelium overlying the lymph deposits in the tonsil, oropharynx, nasopharynx, and the base of the tongue. The primary growth may be nothing more than a slight roughening, which can be detected only by careful digital investigation.

Enlarged lymph nodes in the parotid or subparotid areas require investigation of the parotid gland and the adjacent areas of the scalp. Sebaceous cysts in this area may become squamous cell carcinomas and metastasize early. Tumors in various other parts of the body may also metastasize to the neck.

Biopsy is frequently necessary to distinguish between benign and metastatic lymphadenopathy. It sometimes indicates the previously unrecognized site of the primary tumor or confirms an existing suspicion.

In certain types of both primary and metastatic tumors the lymph cells are neoplastic, hence the term lympho-epithelioma. The balance between epithelial and lymphoid neoplastic cells varies from tumor to tumor. Lympho-epithelioma is particularly likely to arise in the fossa of Rosenmüller of the nasopharynx.

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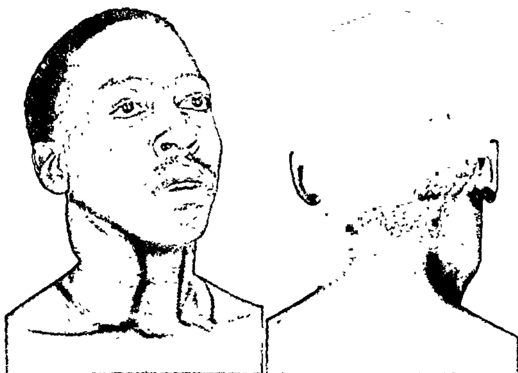


*Figure 124* Lympho-endothelioma Massive involvement of deep cervical nodes metastatic from minute primary tumor in nasopharynx. Biopsy scar is visible as well as fields marked off for deep roentgenotherapy.



*Figure 125* Metastatic involvement of jugular node from carcinoma of the left tonsil.

Often there is ulceration of the overlying skin, with necrosis, sloughing and eventually hemorrhage. The axillary, inguinal and mediastinal lymph nodes all become involved. In an occasional case a whole group of nodes, or all the nodes in the body, seem to become explosively sarcomatous.

Until the disease is fairly far advanced, there are few symptoms or none at all. Later stages are characterized by fever, chills, loss of weight and weakness. As the lymph node involvement increases, it causes pain and pressure symptoms.

Diagnosis is by biopsy, which should be carried out without delay, for some

patient must follow immediately after hemostasis.

*Prevention of Infection.* All accidental wounds are contaminated with bacteria by the time the surgeon sees them. These bacteria are, in part, pathogenic and invade locally, so that infection of a minor degree is always present. The surgeon's aim is to keep the infection minimal and subclinical and to minimize its deleterious effect on wound healing.

Probing a wound with an ungloved finger obviously increases contamination. Antiseptics should be avoided, because they kill previously viable tissue. Because they have been so widely used by the laity, the patient may expect their application, but they should rarely be used in an open wound.

Nature defends the wound against infection through the mechanism of its blood supply. Any factors that decrease blood flow to the wound predispose to infection. This deficiency in the blood supply, however, may be natural. Thus infection, tissue necrosis and slow healing are much more frequent over the pretibial area than in the neck. Multiple lacerations, the pressure of a hematoma, a tight dressing or tight sutures may lead to ischemia. Above all other factors, nonviable tissue, with its lack of blood supply on the one hand and its function as a culture medium for bacteria on the other hand, promotes infection. Ischemia must, therefore, be prevented, and nonviable tissue must be excised. In addition, dirt and other foreign bodies should be removed by irrigating the wound.

Antibiotics, especially penicillin, should be used prophylactically in all major contaminated wounds. Penicillin, 300,000 units, should be given intramuscularly each day for the first 2 or 3 days. When, in the treatment of ambulatory patients, parenteral therapy is not feasible, oral administration of sulfadiazine (1.0 gm. four times daily) remains an excellent adjunct to therapy. In addition to antibiotics or chemotherapy, tetanus antitoxin, or a booster dose of tetanus toxoid in previously immunized patients, should be administered to all patients with a puncture-type wound (see Chapter 11).

*Removal of Nonviable Tissue and Foreign Bodies.* Devitalized tissue and foreign bodies retard or prevent the healing of a wound and often promote infection. Ultimately, the natural wound response causes sloughing of the devitalized tissue, but in the case of fascia, this may require weeks; healing will occur much earlier if the devitalized tissue is excised primarily. Similarly, a wound may heal slowly around a foreign body, but the inflammatory response may persist for months.

It is difficult to differentiate viable from nonviable tissue in the fresh wound. Bleeding from a cut surface is reasonable evidence of viability. Contraction of a muscle, when stimulated by mechanical pinching, is another indication of viability. When the surgeon is in doubt about viability, conservation of tissue is advisable. Injury to the ischemic tissue, such as fascia, tendons and fat, often results in nonviability. Unattached tissue is removable by wound irrigations. Military experience (based on injuries inflicted by fairly high velocity missiles with extensive indirect injuries to adjacent tissues) has demonstrated the need for fairly radical débridement of wounds. Most civilian injuries are lacerating rather than blasting in type, and indirect trauma is minimal. For this reason, wide excision of the fresh wound encountered in civilian life is seldom necessary. When a flap of tissue has been devitalized, however, it must be excised.

In most open wounds, foreign bodies consist of dirt, fragments of clothing, or fragments of the wounding agents. The best means of removing these tiny, ill recognized foreign bodies is by washing and scrubbing the wound. If the wound appears clean, it should routinely be vigorously irrigated with sterile water, a procedure which is effective and not particularly painful. In addition, the wound which has dirt ground into its surface should be scrubbed. Under regional block anesthesia or under local anesthesia, a sterile brush and soap should be used literally to scrub the surface

*Chapter 9*

# Mechanical Injuries

*By John M. Howard*

## WOUNDS

Trauma produces not only local destruction of tissue but also generalized injury to the entire body. An open wound involves four different types of injury:

1. Blood is lost.
2. The defense against bacteria is broken.
3. Tissue is destroyed.
4. Mechanical defects may result.

These four factors are not limited to the traumatized area. Hemorrhage, infection, tissue necrosis, and mechanical derangements injure the entire body and thus provoke a response of every organ and system in the body. With major wounds, the systemic insults (hemorrhage, infection) may be of tremendous importance. With minor wounds, emphasis is usually on local injury and prevention of future complications of wound healing.

Nature has provided the body with an extremely effective healing response to the various factors involved in the wound. Thus, there is, immediately after injury, vasoconstriction and retraction of blood vessels to stop local hemorrhage. Wound contamination is followed by antibody and leukocytic responses to combat infection. An exudate becomes apparent within the first 24 hours after injury. Necrosis and separation of nonviable tissue (slough), which is nature's method of ridding the wound of devitalized tissue, becomes apparent within 48 to 72 hours. Finally, wound repair is achieved by proliferation of capillaries, fibroblast, and epithelium, which begins within 48 to 72 hours after injury. Thus, there is an immediate response to halt progression of the injury, a slower response to prepare the wound for healing, and, after a short time, an actual reparative process. These natural responses are adequate to heal most wounds.

The surgeon's responsibility is to aid the body's response in the following priority:

1. Control of hemorrhage and correction of any major blood volume deficiency.
2. Prevention of infection.
3. Removal of nonviable tissue.
4. Correction of mechanical defects.

***Control of Hemorrhage and Correction of Any Major Blood Volume Deficiency—Hemostasis.*** Although nature obtains hemostasis by vasoconstriction and vascular retraction, large vessels may not be able to contract sufficiently to control bleeding, and application of a hemostat may be life-saving. If hemostasis has not been achieved spontaneously by the time the patient is seen, it is usually a simple matter to clamp and ligate the bleeding vessels. If necessary, the wound may be enlarged under local anesthesia, to permit visualization of the bleeding vessels. A vessel which is incompletely severed cannot retract and, therefore, may continue to bleed. Pressure by the finger or tourniquet may be used as an emergency measure to stop hemorrhage. A pressure dressing is often of assistance in controlling diffuse bleeding. Clamping and ligation of all bleeding vessels are, however, desirable. If bleeding has ceased spontaneously, the wound should not be disturbed prior to operation lest bleeding recur.

Severe bleeding with resultant hypotension may result from small wounds if major blood vessels have been lacerated. Replacement of blood volume in such a

form on such an exposed surface and permit healing with minimal discomfort. Epithelization occurs rapidly beneath the eschar. If infection develops, the eschar must be removed. Topical medication appears inadvisable.

***Lacerations.*** These tearing or incision-type wounds are made most frequently by knives, glass, or sharp edges of tin cans. Injuries to nerves, tendons or vessels frequently complicate lacerations and should always be suspected. These constitute the most common injuries encountered by the surgeon. The principles of wound management, previously discussed, are primarily applicable here.

Lacerations of the face and neck demand careful attention. Because the blood supply in this area is so abundant, primary closure is almost always possible. Since the cosmetic result here is so important, cleansing of the wound and reapproximation of tissue with fine sutures should be meticulously performed.

***Penetrating Wounds.*** Penetrating wounds are of two general types: (1) puncture wounds made by knives, nails, ice picks, and can openers and (2) those produced by shotgun, rifle or other weapons.

The puncture wound has two characteristic clinical hazards. First, it may produce injury to a deep organ, as in penetration of an intra-abdominal viscus, without obvious clinical manifestations. Second, it is notorious as the site of tetanus infection. The patient with a puncture wound must, therefore, be carefully examined for evidence of major internal injuries. It is usually advisable to make roentgenograms in search of a foreign body. If no foreign body is found, the superficial wound should be irrigated. Excision is seldom indicated. Tetanus antitoxin, or a booster dose of tetanus toxoid, should be administered routinely.

Gunshot wounds are often serious problems involving large areas of tissue destruction. Many retain foreign bodies and the incidence of major injuries, such as fractures or visceral perforations, is high. Hospitalization is often required for exploration and débridement of the wound. Small wounds may be cleansed and treated conservatively without débridement. Bullets are small metallic foreign bodies (Fig. 126), but they are often less dangerous than are the attempts to remove them. Bits of clothing and dirt are foreign bodies that produce infection and, when recognized, should be removed.

***Foreign Bodies.*** The practicing physician encounters many humorous as well as pathetic incidents involving foreign



*Figure 126.* This foreign body (bullet) was localized on the anteroposterior and lateral films. As it was in a weight-bearing area, it produced pain and necessitated removal.

while the wound is irrigated with copious quantities of water.

*Correction of Mechanical Defects.* If the mechanical defect is a life-endangering injury, such as a tension pneumothorax or intestinal perforation, or is a limb-endangering injury, such as a major fracture, its correction deserves an extremely high priority in surgical care. In minor surgery, however, the mechanical defect of most frequent concern is the separation of the edges of tissue—the open wound.

After the factors deleterious to wound healing (bleeding, infection and devitalized tissue) have been controlled, attention must be directed to promotion of wound healing by reducing the size of the wound by suture or by skin graft. A gaping wound is obviously a larger defect and requires a longer time to heal than does a closed wound.

The extent of the wound must first be ascertained preoperatively by inspection without exploration of the wound, by determination of the pulse and skin color distal to the wound for evidence of vascular injury, by estimation of neural function, and, in selected patients, by roentgenographic examination for evidence of fracture or retained foreign body. The extent of the injury should then be re-evaluated by exploration under anesthesia

Next the wound should be thoroughly cleansed of foreign bodies and nonviable tissue, and the tissues should be reapproximated In the treatment of most lacerating wounds, fascia, tendons, nerves, major arteries and skin should be reapproximated by primary suture. If a wound appears grossly clean when seen within the first 24 hours after injury, it should be closed primarily. Wounds more than 24 hours old can probably best be closed on the third or fourth day, as infection is more likely if closure is attempted earlier.

Soft tissue wounds can usually be closed under local or regional anesthesia. Nonabsorbable sutures are frequently used in repairing these wounds, but, in general, use of absorbable sutures beneath the skin of contaminated wounds appears preferable.

The principle of repair is accurate reapproximation of the tissue without destruction of additional tissues. Obviously, a wound hematoma prevents accurate reapproximation. Any dead space will become filled with serum and provide a site for secondary infection. If tension by suture is employed for approximation, resultant ischemia may lead to further destruction of tissue, and increased size of the wound. Rather than suture a wound primarily under too much tension, it should be extended to permit plastic repair, closed with a split-thickness skin graft, or only partially closed.

### Treatment of Specific Types of Wounds

*Contusions.* A contusion is a bruise. In itself a nonpenetrating wound produced by a blunt force, it is nonetheless often associated with lacerations and with hemorrhage into the injured tissues. Since the injured tissues are usually viable, treatment should be conservative. If the skin is not broken, surgical exploration of the deeper wound is rarely indicated. Because of hemorrhage beneath the skin, a contused area often turns blue and later yellow. Examination and continued observation seldom demonstrate need for definite therapy unless an associated fracture is found.

*Abrasions.* These injuries are superficial wounds, comparable in depth to a second degree burn. They result from friction, as when a basketball player slides across the floor. Being superficial and often involving large surface areas, they leave many nerve endings exposed and, therefore, prove extremely painful. Unlike the second degree burn, they often have clothing or dirt ground into the skin. Such foreign bodies must be removed by irrigation or occasionally by scrubbing with a brush. Thereafter, treatment is similar to that of superficial burns. If a weight-bearing surface, such as the feet, buttocks, or back is involved, a protective layer of petrolatum gauze should be applied and covered with a plain dressing. If the abrasion is in an area that can be protected from pressure, no dressing is required. An eschar may

prophylaxis against tetanus should be administered routinely. If the surgeon believes that all the dirt has been removed and therefore closes the wound, he should prescribe antibiotics or chemotherapy for several days thereafter and should keep the patient under careful observation.

*Wooden Splinters.* Wooden splinters are encountered primarily in the feet of children or in the hands of people of any age. This type of foreign body, which is always contaminated, comes from a rough board, especially rough flooring. It is usually removed by a member of the family and rarely comes to the attention of a physician. Because of its location in a weight-bearing or mobile portion of the body, the splinter produces a painful wound, particularly if it lies beneath the finger nail or toe nail.

Localization is usually simple, since the splinter has a clearly defined wound of entry, travels in a straight line and lies relatively superficially. Unless painted, it will probably not be visible roentgenographically.

For splinters in a digit, injection of procaine around the base of the digit will anesthetize it so that the wound may be incised, the splinter withdrawn along its path of entry, and the wound thoroughly irrigated. If the splinter lies beneath the nail, a V-shaped excision of the nail overlying the splinter will permit its removal. In other parts of the body, it may be necessary to infiltrate the local area with procaine, enlarge the wound of entry, and grasp and withdraw the splinter with a hemostat. The site should then be carefully examined for residual foreign bodies. Finally, the wound should be thoroughly irrigated with sterile water.

*Needles.* Occasionally, injury occurs when a patient sits or steps on a sewing needle in such a way that it becomes embedded or broken beneath the skin (Fig. 127). A similar but more frequent injury is sustained when a hypodermic needle breaks subcutaneously. Such accidents may occur during administration of medicine to crying, squirming children or self-administration of insulin

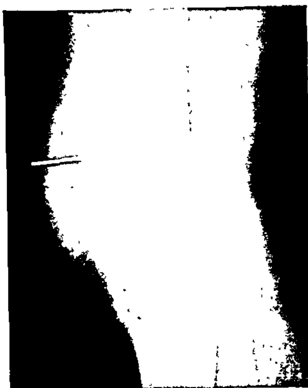


*Figure 127.* The lateral view was essential in localizing this broken needle.

in older, diabetic patients. Because these slender, metallic fragments are extremely difficult to locate surgically in the thigh, buttocks or arm, it is probably best to leave them alone. However, when a physician is himself responsible for the accident, he is usually anxious to remove the foreign body. If removal is attempted, the needle should be localized roentgenographically, as described, anesthesia should be complete, and the surgeon should be prepared to spend as much as one or two hours searching for the fragment. Fluoroscopic guidance is occasionally of assistance.

Needles in the hands or feet are more painful but are easier to localize. If removal appears feasible, and especially if the resultant wound is symptomatic, the foreign body should be removed.

*Cloth.* Cloth is introduced into wounds in two ways: (1) fragments of clothing may be carried into the wound by the penetrating agent, and (2) sponges may be left in the wound by the physician. Such wounds will become infected and continue to drain indefinitely. Re-exploration in search of the foreign body is indicated. This can usually be achieved adequately under local anesthesia by

bodies, particularly in children. For example, a child who had seen a magician pack cotton in his ear and "pull it out his nose" attempted to repeat the trick and packed cotton into his middle ear. Certain characteristics of foreign bodies influence their treatment. They usually enter the soft tissues through a puncture wound. Frequently, the puncturing agent is removed, but the patient does not know whether removal was complete or partial.

Most foreign bodies are not absorbable. The nonabsorbable one, if not removed surgically, may produce an infection, be removed spontaneously during the ensuing drainage, or undergo fibrous encapsulation. A few deep-lying foreign bodies may migrate as a result of adjacent muscular contraction.

Foreign bodies that are grossly contaminated, such as wooden splinters, dirt, clothing or fish bones, almost inevitably result in infection. Bullets, broken hypodermic needles or sewing needles are less irritating and, as the former two may be less contaminated, infection is not as apt to develop. Infection around any foreign body may not be clinically apparent for weeks or months, only to flare up at a later date. Any wound that does not heal completely but continues to drain should be suspected of harboring a foreign body.

Treatment of foreign bodies must be governed by individual circumstances. The following generalizations, however, apply.

1. Foreign bodies that protrude through the skin should be removed.

2. Foreign bodies that are symptomatic should be removed.

3. Wooden splinters, dirt and cloth should be removed.

4. Metallic foreign bodies should not be removed if operation is likely to produce greater damage than the foreign body. Small, deeply embedded foreign bodies may be extremely difficult to locate surgically. Removal of such an object should not be undertaken without serious consideration of the difficulties involved.

5. Puncture wounds associated with foreign bodies are a potential site of tetanus. Tetanus antitoxin, or a booster dose of tetanus toxoid, should be administered routinely.

6. Any wound that continues to drain or heals superficially, then reopens and begins to drain, should be suspected of containing a foreign body.

7. Before attempting to remove any embedded foreign body, the surgeon should make every effort to localize it as precisely as possible. The site of entry, the area of pain or tenderness and the possibility of palpating it are clinical aids. Roentgenograms should be made routinely, including anteroposterior and lateral views. It is often essential to relate the position of the embedded foreign body to the surface anatomic structure. This can sometimes best be performed by strapping one or more radiopaque substances, such as a pin or staple, to the skin prior to taking the film. The pin is retained in situ until the time of operation, when it may be removed and its site marked with a sharp needle point.

8. Foreign bodies may become symptomatic after a lapse of many months, warranting excision at this late date.

9. Local anesthesia is often satisfactory if the site of the foreign body is known precisely. If the exact site cannot be detected preoperatively, regional anesthesia is preferable.

10. Hemostasis must be perfect in order that the surgeon may locate the small, deep-lying foreign body. A tourniquet is sometimes a useful adjunct to therapy.

11. Once the incision is made, the foreign body may best be located by probing with a sharp instrument, such as a needle, in a direction perpendicular to the long axis of the foreign body.

*Dirt.* The most common of all foreign bodies, dirt, is present in most types of accidental wounds Its presence may be assumed if the wounding agent had lain on the ground. If dirt is visible in the wound, its extent is probably sufficient to require excision or incision of the wound edges and thorough washing All wounds that have been contaminated by soil should be thoroughly irrigated, and

is a dental injury rather than an actual bite. It results in a wound across the dorsum of the metacarpophalangeal joints. This type of injury accounts for many of the human bites of the hand, although not infrequently a patient may be seen whose antagonist has produced deep circumferential wounds of the finger. The latter are representative of the second type of injury, which results from an actual bite. The face is a common site of injury, where a bite may produce a deep wound or a wound producing a thick "skin flap."

These wounds are inoculated with a highly pathogenic, mixed bacterial flora. If left untreated, the resultant foul smelling wound will persist for weeks.

*Treatment.* Under local or regional anesthesia, the wound should be thoroughly scrubbed with soap and water. Débridement should be conservative but meticulous, after which Crikelair and Bates[1] recommend closure of wounds of the face.

Wounds of the hands[2] produce a higher incidence of complications, owing to the frequency of injuries to fascia and tendons. Wounds of the fingers should be cleaned, débrided and left open for 3 or 4 days. Many will not require secondary suture.

Antibiotics should be given routinely and persistently for all such injuries. The adage "Treat human bites twice as long as you think they need treatment" reveals the experience surgeons have had with chronic infection. Since the tetanus bacillus is not a normal inhabitant of the mouth,[3] tetanus is an unusual complication.

Because of the nature of the injury, the patient frequently does not seek medical care until he had a badly infected wound. Like many patients with fresh wounds, such patients should be hospitalized. A therapeutic program of warm soaks, immobilization and antibiotics should be instituted and should not be discontinued until the inflammation has almost completely subsided.

### Animal Bites—Rabies

See page 186.

### Insect Stings

Hornets, wasps, yellow jackets, bumblebees and honeybees produce a painful sting with a severe local reaction. Local application of mildly alkaline compounds, such as sodium bicarbonate, is standard home treatment but is of doubtful value. Occasionally, a person sensitized by the toxin of a previous sting will collapse when stung again. Dyspnea, cyanosis, urticaria, and unconsciousness may develop. Miller[4] recommended intravenous administration of calcium gluconate, 0.2 cc. per kilogram of body weight, up to 20 or 30 cc., accompanied by Benadryl, 5 mg. per kilogram. As in other anaphylactic reactions, 1 cc. of 1:1000 epinephrine may afford relief.

### Black Widow Spider (*Latrodectus mactans*) Bites

In the United States the black widow spider is found predominantly in the southern and western states but has been reported in every state of the union. The female of the species, the poisonous one, is glossy black with a distinguishing bright red hourglass on its ventral surface. The sting is suggestive of a needle prick but is followed by a burning pain which becomes dull and aching as the venom spreads through the lymphatic system. The burning may become generalized and may be associated with muscular cramping and rigidity. Occasionally, death results directly from the effects of the poison or indirectly through secondary effects on the circulatory system, suggestive of a cerebrovascular accident.[4]

An antivenom from hyperimmune horse serum is available for intramuscular injection but its efficacy remains questionable. Miller[4] recommended its use together with the intravenous administration of calcium gluconate.

### Scorpion Stings

The scorpion is found throughout the southern and southwestern regions of the United States and throughout the tropical countries of the world. Injury is produced by injection of a venom through the insect's stinger, located in its tail.

incision of the draining sinus and passage of a probe along the tract to its depth. This may lead directly to the foreign body. Removal of the foreign material will be followed by formation of healthy granulation tissue, subsequent closure of the tract and healing of the skin.

*Sutures* Nonabsorbable sutures, especially silk and cotton, are foreign bodies in wounds which may act as a nidus of infection. Usually, these small sutures are asymptomatic and eventually become encapsulated with fibrous tissues. Frequently, however, chronic infection in the wound during the immediate postoperative period causes it to continue to drain. The sutures become the site of an annoying chronic infection. In such wounds sutures may continue to slough for months. Healing may be hastened by opening the wound and removing the offending sutures; anesthetization is usually unnecessary since the nerve supply has not had time to regenerate.

In other instances the wound may heal primarily and appear perfectly normal for months, only to show evidence of infection later Blebs may then form in the scar, open spontaneously, and continue to drain. A sterile nerve hook may sometimes be inserted into the drainage tract and the suture thus caught and removed. Most frequently, the offending suture or ligature is in the subcutaneous tissue but occasionally it lies in the deeper layers.

*Glass.* Glass has three modes of entry into human tissue. Children may step on broken bottles or glasses, fragments of which may break off beneath the skin of their feet. Adults may break glass objects in their hands, forcing slivers of glass to become embedded in the tissues Finally, fragments of broken windshields and windows in automobile accidents may become embedded in the upper part of the body.

Because most glass contains little lead, it may not be visible roentgenographically. Furthermore, the patient is seldom certain that any glass has remained in the tissues. For this reason, its removal is difficult. Because it may occasionally be of value, a roentgenogram should be taken. Even if no abnormality is detected in the film, exploration is indicated, if pressure on the overlying tissues produces pain. After the wound has been incised, the foreign body is best located by the resistance felt as the probe touches the glass.

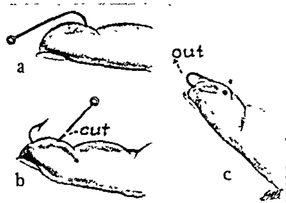



*Figure 128.* Demonstrating how the barb may be rotated forward, the shaft severed, and the hook withdrawn.

*Fishhooks.* Fishhooks present an unusual problem in the management of foreign bodies. They become partially embedded, most frequently in the fingers, and are so designed that the barb prevents their withdrawal. For this reason, either the wound must be incised or the hook pushed forward as demonstrated in Figure 128. In the latter maneuver, the hook is rotated in such a way that the point penetrates the skin. After the point is grasped with a hemostat, the shaft of the hook is divided and the hook is extracted by pulling the point forward in an arc.

### BITES AND STINGS

Bites and stings are of medical importance when they produce (1) contaminated (nonspecific) wounds (human bites), (2) wounds inoculated with a specific disease (rabies), and (3) wounds inoculated with specific toxins (snake bites, insect stings, stingray wounds).

#### Human Bites

Human bites are serious injuries which are generally neglected by many doctors.

*Characteristics.* Human bites follow two patterns The first, produced when a fist strikes an opponent in the mouth,

United States, however, secrete a proteolytic enzyme, which produces local gangrene and widespread cellular destruction.

The experienced zoologist can inspect a wound and distinguish the bite of a poisonous snake by the pattern of the fang marks; the average physician can only assume that the snake was poisonous. He often has no other choice, for the snake may not have been recognized by the patient.

*Clinical Manifestations.* The snake bite is followed by severe burning pain at the local site. For the first 15 minutes there will be little indication except two puncture marks and a little edema, which spreads rapidly. If treatment is not available, ecchymoses are followed by more extensive hemorrhage. Hemolysis is severe enough to produce anemia. The patient becomes extremely thirsty. Nausea, vomiting and shock may occur. The involved extremity may be so swollen that ischemic necrosis results.[4] Death may ensue. In untreated cases the reported mortality rates have varied to such an extent that it is difficult to determine the prognosis. The prognosis in children is graver than in adults, whose injuries are rarely fatal. Swartzwelder[15] reported a mortality rate of less than 1 per cent among 306 patients admitted to Charity Hospital in New Orleans.

*Treatment.* Treatment is directed at retarding the rate of absorption of the toxin, removing the toxin, neutralizing the circulating toxin and supporting the blood volume.

The first-aid measures are probably the most effective and yet account for the greatest number of complications Treatment is empiric, few physicians having had an opportunity to evaluate the therapeutic measures carefully. Absorption of the toxin is retarded by placing the extremity in a dependent position or applying a tourniquet proximal to the bite. The efficacy of the latter treatment has been questioned[16] but remains standard practice. Some physicians do not apply the tourniquet tightly enough to occlude the arterial flow but only enough to impede lymph flow.[17] If tightly applied, the tourniquet should be released hourly for 5 minutes, for gangrene, with resultant amputation, has followed use of the tourniquet for this purpose.[18]

Cruciate incisions are then made through the fang marks and suction is applied to the incision. If the glass suction set is not available, the mouth may be used Suction should be applied continuously as long as it appears to be achieving its purpose. The venom removed by oral suction is not likely to affect the recipient. Cruciate incisions through the skin and subcutaneous tissue are then made proximally along the route of lymphatic drainage[18] in order to interrupt the lymphatic vessels and permit external drainage of toxin-bearing lymph.

Polyvalent antivenom, commercially prepared by injecting venom into horses, should be given after the patient has been skin tested. It is an antivenom for all poisonous snakes of North America except the coral snake. Each ampule of this dried serum is mixed with 10 cc. of saline and is sufficient to neutralize 20 mg. or more of the venom. Thus, 5 to 15 ampules may be needed to neutralize the anticipated amount of venom. Such calculations are, at best, rough approximations. The antivenom is injected into the wound, into the swollen extremity and into the buttock. Blood is administered as needed to support the blood volume.

Antibiotics should be administered to prevent secondary infection.

The entire therapy of snake bite deserves a critical experimental review, for the present therapeutic regimen is based neither on broad clinical experiences nor on sufficient experimental data.

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The immediate local manifestation is severe pain. Within two hours the venom becomes sufficiently absorbed to produce systemic manifestations, including nervousness, nausea, vomiting, loss of sphincter control, thirst and abdominal pain. Fatal cases progress to shock, dyspnea, cyanosis, paralysis, convulsions, delirium and coma.[5] Most fatalities occur in infants, in whom the concentration of venom is presumably higher because of the victims' small size. Adults seldom suffer serious effects.

Symptomatic treatment consists in local application of mildly alkaline compounds, such as sodium bicarbonate. Convulsion requires treatment with sedation. An antiserum is now available which appears to be effective[6] and should be used in treating children.

### Stingray (Stingaree) Stings

The stingray, a species of shark, is a flat, kite-shaped fish with a long whiplike tail. Those rays that have one or more long, sharp, serrated spines on the tail are called stingrays, a word corrupted to stingarees. Several dozen species are known. They are encountered in all warm oceans and bays and the adjacent portion of rivers. When disturbed, the stingray swims close to the bottom and stirs up a cloud of sand or mud. As it comes to rest on the bottom, the cloud of mud settles over it. It is in this half submerged position that a person may step on the stingray. The stingray then whips its tail around its victim's leg, driving the spine or sting into the soft tissues or bones. The spine may, or may not, break off[7,8] The sting is one of the most painful of all wounds, causing the victim to cry with sudden pain. Vellard[9] demonstrated a venom from South American stingrays that was occasionally fatal to animals.

Little is known about treatment. Evans[10] recommended injection of a few drops of 5 per cent solution of potassium permanganate into the wound for relief of pain.

### Jellyfish Stings

There are many species of jellyfish, and the discomfort resulting from stings varies from species to species. The sting is a problem of bathers, particularly in tropical waters. The sting of the jellyfish that exists in temperate waters[11] usually results only in discomfort, whereas that of the tropical species apparently may be much more serious.

The sting is produced by thousands of little barbs which inject a toxin. When a trigger hair is touched, the tiny harpoon-shaped barbs protrude and penetrate the outer layer of the skin. Few data are available as to the nature of the toxin.[12] Initially, an intense burning results around the site of the sting. After a few minutes an urticaria-like wheal may form, which later may result in a blister. After the first few hours the pain may disappear, only to recur unexpectedly at intervals for days thereafter. In the more severe instances, the sting may be followed by muscular spasms, which may involve lumbar and abdominal muscles as well as those of the extremity. Lacrimation, mucosal congestion, dilatation of the pupils and respiratory difficulty may lead to an alarming syndrome. Therapy in the mild syndromes has been ineffectual; in the more severe syndromes morphine and the intravenous injection of calcium gluconate (10 cc. of a 10 per cent solution) have been used empirically.[12]

### Snake Bites

The poisonous snakes of the United States include primarily the rattlesnake, water moccasin, copperhead and coral snake. The first three are distributed throughout the United States. The coral snake, the most poisonous of all, fortunately has a limited geographical distribution in the South.[13]

Snakes produce their venom in salivary-type glands and inject it into their victims through hypodermic-like canals in their two upper fangs. According to Keeley,[14] the rattlesnake injects about 225 mg. of venom, the water moccasin about 150 mg and the copperhead about 45 mg.

Some snakes, such as the cobra, secrete a fluid that is primarily a neurotoxin producing respiratory paralysis. The three major groups of snakes in the

*Chapter 10*

# Thermal, Chemical and Electrical Injuries

*By B. W. Haynes, Jr.*

## BURNS

Burns may result from contact with flame, hot water, metals or other elements, steam, acids, alkalies, roentgen rays, electricity, sunlight, ultraviolet light and irritant gases.

*Classification.* For therapeutic and prognostic purposes, burns may be classified as (1) first degree (erythema of the skin), (2) second degree (vesicle formation, indicative of epidermal and dermal damage), or (3) third degree (complete involvement of the epidermis and dermis, extending into or beyond the subcutaneous tissue) (Fig. 129). It is often difficult, if not impossible, to distinguish initially between the last two, but early differentiation is helpful in planning therapy, since second degree burns will regenerate spontaneously, whereas third degree burns require skin grafting. Absence of pain to pinprick is suggestive of a third degree burn. Recognition of the potential intensity and duration of exposure to the causative agent is of importance in estimating depth of injury. For example, hot water generally causes a burn which is less destructive of the deeper tissues than does a flame, since the intensity (temperature) of a flame is much greater than that of hot water and, similarly, the duration of exposure is frequently longer. Flash

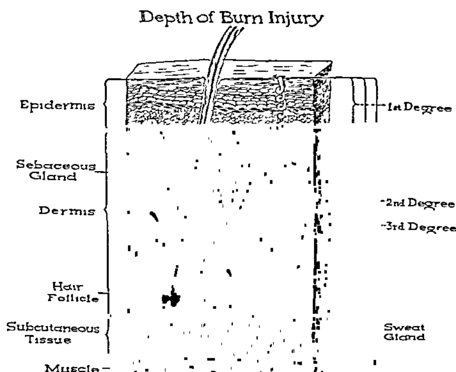



*Figure 129.* Classification of burn injury by degree according to depth of tissue destroyed.

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nomatous degeneration of the skin has been observed following burns, particularly in association with extensive scars of long duration (Marjolin's ulcer).

Various pathologic changes have been observed in virtually every organ following lethal thermal injury. In the liver, fatty degeneration and central necrosis are common. During the era of tannic acid treatment, many deaths resulted from hepatic damage, characterized by jaundice, coma and a rapid downhill course. It is reasonable to attribute the hepatotoxic effect to absorption of tannic acid from the wound. Since this agent is no longer generally employed, hepatic injury appears to be a much less common cause of death.

The adrenal changes resemble those following any severe injury which imposes great stress on the adrenal gland. The gland appears grossly swollen, and microscopic examination often reveals focal hemorrhage. In patients with burns of long duration, depletion of epinephrine and cortical lipoids has been observed.

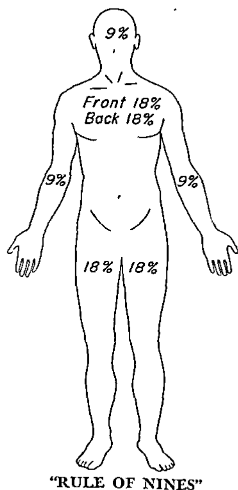



*Figure 130.* Simplified chart of percentage body surface area according to Wallace.

Variable alterations in the kidneys, including proximal and especially distal tubular necrosis, hemoglobinuric casts and venous thrombosis, are associated with early shock and can usually be prevented by adequate energetic therapy. In our experience, renal failure as a cause of death is extremely unusual and occurs chiefly as a terminal event in association with peripheral vascular failure. Such patients do not die of acidosis and hyperkalemia, but of shock, unresponsive to any known treatment. Other organs, such as the heart and lungs, have exhibited inconstant changes.

Curling's ulcer, a gastrointestinal lesion associated with severe deep burns, has been reported in 3.8 per cent of 680 fatal cases. It is typically found in the first portion of the duodenum and may be accompanied by hemorrhage or perforation.

***Pathologic Physiology. Fluid and Electrolytic Abnormalities.*** After a burn, edema, which is an essential response to any injury, develops. The swelling has a beneficial effect by bathing the wound in a fluid containing proteins, tryptic enzymes, leukocytes and antibodies. In extensive burns there is, however, loss of a significant *volume* of fluid into and from the wound, sufficient to cause hypovolemia and shock. After a thermal injury, the capillaries of the burned area undergo changes in permeability which promote leakage of plasma-like fluid into the wound. Moreover, the blood flow to the area increases so that a larger volume of plasma flows through the wound. Blebs appear. They contain approximately 5 gm. of serum protein per 100 cc. as compared to 1 to 2 gm. per 100 cc. in lymph. The fluid in blebs contains sodium, potassium, bicarbonate and other substances in concentration equal to that of plasma.

Edema develops immediately after injury, progressing most rapidly during the first 8 hours and reaching its peak 36 to 48 hours after injury. At that time,

*Table 1.* Table of Surface Proportions (Percentages) in Detail

| Area | Age | | | | | |
|---|---|---|---|---|---|---|
| | *Birth* | *1* | *5* | *10* | *15* | *Adult* |
| Head. | 19 | 17 | 13 | 11 | 9 | 7 |
| Neck | 2 | 2 | 2 | 2 | 2 | 2 |
| Anterior trunk* | 13 | 13 | 13 | 13 | 13 | 13 |
| Posterior trunk† | 13 | 13 | 13 | 13 | 13 | 13 |
| Buttocks | 5 | 5 | 5 | 5 | 5 | 5 |
| Genitalia | 1 | 1 | 1 | 1 | 1 | 1 |
| Upper arms | 8 | 8 | 8 | 8 | 8 | 8 |
| Forearms | 6 | 6 | 6 | 6 | 6 | 6 |
| Hands | 5 | 5 | 5 | 5 | 5 | 5 |
| Thighs | 11 | 13 | 16 | 17 | 18 | 19 |
| Legs | 10 | 10 | 11 | 12 | 13 | 14 |
| Feet | 7 | 7 | 7 | 7 | 7 | 7 |
| Total | *100* | *100* | *100* | *100* | *100* | *100* |

* Without neck or genitalia.
† Without neck or buttocks
(From Lund and Browder Surg., Gynec. & Obst., *79* 352, 1944.)

burns are typically superficial in depth and profile; the exposed surfaces, such as the face, the hands, and in women and children, the legs, are chiefly involved Whereas the depth of the burn has a strong influence upon mortality and morbidity, its accurate estimation at the time of injury is not absolutely essential for success of early treatment. Within 10 to 14 days the degree of burn becomes apparent.

The extent of a burn is best estimated in terms of the percentage of body surface area involved. Lund and Browder's modification of the original Berkow chart shows in detail the variation in percentage area occupied by the various parts of the body at different age levels[1] (Table 1). Wallace designed a practical chart which is extremely helpful in estimation of fluid requirements. His "Rule of Nines" (Fig. 130), which assigns to various areas of the body 9 per cent of surface area or multiples thereof, approximates true surface area accurately enough to permit adequate estimation of fluid requirements. Furthermore, because this simple diagram is so easily learned, it is readily available for use.

***Pathology.*** After a first degree burn, the skin initially becomes blanched as a result of intense vasoconstriction. Vasodilatation, mild edema and erythema soon develop. *Microscopic intra-epithelial* blisters may form. Three or four days later, the superficial epithelium sloughs (peels), leaving beneath healthy, regenerating epithelium.

After a second degree burn, rapid collection of vesicular fluid separates the epidermis into layers. Cutaneous necrosis is more extensive than in first degree burns, and leukocytic invasion is prominent. Sloughing results from leukocytic enzymatic action or autolysis, and epithelial healing is usually complete by the tenth to fourteenth day.

Third degree burns produce complete destruction of all layers of the skin. A zone of separation begins at the deepest level of necrotic tissue, which is infiltrated with leukocytes. Suppuration is common. Within two to three weeks sloughing occurs and simultaneously the capillaries regenerate to cover the wound with a spongy red network. If skin grafting is not performed, epithelium grows in slowly from the periphery, accompanied by obliteration of the capillaries and development of cicatricial fibrous tissue. Dense scars result in contracture with consequent pronounced deformity and impaired function. If there are islands of undestroyed sweat gland or sebaceous gland tissue in an area of third degree burn, these will regenerate epithelium which spreads concentrically to produce *epithelial healing*. Carci-

terized by a negative nitrogen balance lasting from two to four weeks. During the first three or four days after injury, this destructive phase is interrupted temporarily by a positive nitrogen balance caused by administration of protein, such as plasma and whole blood. The anabolic phase, beginning two to four weeks after injury, is characterized by a positive nitrogen balance which continues until recovery. Similar changes of less degree can be produced in a normal adult by administration of ACTH. However, in the absence of the adrenal glands such change can be demonstrated in response to trauma provided that a level of circulating corticosteroids is maintained. Ingle believes the action of corticosteroids on protein metabolism to be permissive.[3] Further clarification of these relationships is needed.

During the catabolic phase, the body appears unable to utilize large amounts of either native protein or protein hydrolysates. However, high caloric-high protein diets appear to diminish nitrogen loss during the early days after injury. Although we have not found it possible to maintain a positive nitrogen balance by intensive feeding during the catabolic phase, protein losses may be diminished and loss of weight may be minimized. Dietary intakes of up to 2 gm. of protein and 45 calories per kg. of body weight per day may be administered, beginning with lower levels of intake and working up to these amounts. Further clarification of tissue utilization of protein during this period is needed. It has been observed that debilitated patients frequently fail to respond to stress by increased nitrogen output (catabolic phase) and are able to retain dietary nitrogen on comparatively low intakes, and increased nitrogen intake results in more rapid weight gain than in normal persons.

During the anabolic phase, there is a direct relationship between protein intake and positive nitrogen balance. The greater the intake of protein, the more rapidly the obligatory losses of the catabolic phase are replaced. The protein loss from the burn wound is an important consideration, since, in the early days after injury, a 30 per cent body surface area burn may lose as much as 2000 cc. of fluid per day, or a possible 80 gm. of serum protein (total circulating plasma protein approximately 200 gm.). After three weeks, the unhealed wound loses in exudate up to 30 per cent of all nitrogen lost from the body, as much as 5.5 gm. of nitrogen, which represents 33 gm. of whole protein.

*Potassium and Sodium Metabolism.* During the first two to four days after injury, potassium balance is mildly negative. Increased output of potassium in the urine is caused by destruction of cells by injury and by adrenal hormone activity. Mineralocorticoids (aldosterone) act upon the kidney to increase output of potassium and decrease output of sodium. The deficit of potassium in the usual case can be corrected with intakes of 50 mEq. per day. This amount is provided by an average diet. Intravenous potassium therapy is contraindicated.

In the successfully treated burned patient, there is a large positive balance of sodium caused by administration of large amounts of sodium-containing fluids to replace the losses into and from the burn wound. Diuresis of sodium begins on the second to the sixth day and continues as the edema decreases. Normal balance is usually achieved by the end of the second or third week. Retention of sodium after injury is related not only to intake but, as indicated, also to adrenal hormone function. A normal person given ACTH will show sodium retention and increased potassium excretion for two or three days. This demonstrates the influence of adrenal steroids upon electrolyte excretion.

*Carbohydrate Metabolism.* In the early days after injury, there is frequently a rise in blood sugar which probably reflects epinephrine and glucocorticoid effect upon mobilization of glycogen from the liver. Evans and Butterfield described a "pseudodiabetes of stress," which they believed may be associated with increased ACTH output and "forced feeding" of large amounts of carbohydrate.[4]

capillary diffusion equals capillary absorption plus lymphatic drainage, presumably because of progress of healing and other factors. Factors limiting development of edema following injury are not clearly understood. To some degree they are related to pressure in the tissues caused by the limited elasticity of the intact skin. Edema may subside as rapidly as it develops, but a week or longer is usually required for reabsorption of the fluid into the circulation and its excretion through the kidneys.

Second degree burns produce more edema than third degree burns. The greater elasticity of the skin in the former offers less resistance to formation of edema and favors extensive development of blisters and surface weeping. In third degree burns, on the other hand, the skin is tough and inelastic, limiting the development of edema, and its surface is dry and firm. Lymphatic drainage from the wound rises abruptly after injury, falls shortly as the peak of edema is reached, and remains elevated until healing is complete.

The fluid which produces swelling is derived directly from the blood circulating through the wound. Since the fluid lost from the blood stream contains less protein than plasma, the plasma content of the blood becomes diminished and the protein concentration increases. This results in increased osmotic pressure within the vascular tree, which, in turn, draws on the interstitial fluid of the unburned areas of the body to help relieve the plasma volume deficit. If this fluid is not replaced, the body becomes extremely dehydrated in an attempt to satisfy the insatiable thirst of the burned tissue. Diminished blood volume leads to shock, decreased cardiac output, anoxia and, eventually, death.

*Diminished Red Cell Mass.* In addition to the protein and electrolyte losses, a variable number of red blood cells are destroyed by heat or injury. "Pink plasma" (gross hemolysis), often noted shortly after injury, indicates hemolysis of the red blood cells which have probably been injured in the wound and released into the circulation. As would be expected, the deeper and more extensive the burn, the more red blood cells are destroyed. Ordinarily, the body is able to clear the plasma of free hemoglobin within 24 hours after injury, and the actual quantity of red cells destroyed by this method is usually small. Increase in concentration of red blood cells occurs after injury, as evidenced by an elevated hematocrit value, which may rise from normal to 45 per cent to 60 per cent or higher, because there is a considerable excess of plasma loss over red cell loss. However, direct measurement of the red cell mass in spite of hemoconcentration has demonstrated that an 11 per cent reduction may occur during the first several hours following injury,[2] and this deficit may rise to 30 per cent of the red cell mass within the first week in the severely burned patient. On the fourth or fifth day after injury, anemia develops in the severely burned patient who has not received whole blood. In addition, production of red blood cells is diminished after injury.

*Endocrine Changes.* Impulses arising in the burn would pass over the sensory nerves to the brain. Hypothalamic impulses stimulate the anterior pituitary gland to produce, among others, adrenocorticotrophic hormone (ACTH). This hormone, in turn, activates the adrenal cortex to secrete steroid hormones. Corticosteroids have several important functions within the body. They are concerned with regulation of carbohydrate, protein and fat utilization and electrolyte regulation. For example, cortisone is known to promote gluconeogenesis, and aldosterone is concerned with maintenance of electrolyte framework by control of sodium and potassium excretion by the kidney. Studies of nitrogen and electrolyte balance in severely burned patients reveal a pattern of response which appears to be greatly influenced by the functioning pituitary adrenal axis.

*Protein Metabolism.* There are two primary stages of protein metabolism following injury: (1) catabolic and (2) anabolic. The catabolic phase is charac-

of shock and improved circulation. Occasionally, small doses of barbiturates may be necessary.

After relief of pain has been accomplished, the extent and depth of the burn and the weight of the patient should be determined. These data are of vital importance in the estimation of fluid and electrolyte requirements. The "Rule of Nines" chart (Fig. 130) is helpful in this regard. In any child with a surface area burn of more than 10 per cent, or in any adult with one of more than 15 per cent, pronounced fluid shifts may be expected and prompt intravenous therapy is mandatory. In such instances it is advisable to perform phlebotomy to insure a constant route for infusion. The saphenous vein, exposed under local anesthesia just anterior to the medial malleolus at the ankle, is a dependable site for insertion of a size 18 polyethylene catheter. A catheter of this size will insure passage of blood as well as crystalloid solutions and is not easily clogged. A specimen of blood must be secured for typing and cross-matching. The amount and kind of fluid required are then determined. Based upon decrease in plasma volume as measured by blood volume techniques, Evans and associates derived a formula for calculation of anticipated fluid needs during the stage of edema.[6] For the first 24 hours after injury, the amount of colloid (plasma, plasma substitute or blood) required is determined by multiplying the percentage of body surface area burned by the patient's weight in kilograms by 1 cc. In addition, the same quantity of isotonic saline solution is given plus 2000 cc. of 5 per cent dextrose in water to meet ordinary metabolic requirements for water. For example, the fluid required for the first 24 hours for a patient with a 40 per cent body surface area of burn and weighing 70 kg. (2.2 pounds equals 1 kg.) would be:

| | |
|---|---|
| 1 cc. colloid × 40 per cent body surface area burn × 70 kg. | 2800 cc. |
| 1 cc. saline solution × 40 per cent body surface area × 70 kg | 2800 cc. |
| 2000 cc. 5 per cent dextrose in water | 2000 cc. |
| Total | 7600 cc. |

In order to pace the rate of loss of fluid as wound edema, one-half of the total calculated volume of fluid is given during the first 8 hours and one-half during the following 16 hours.

Selection of the colloid solution to be given depends upon several factors. Based upon the fundamental principle of replacing what has been lost, the ideal solution would contain a combination of red blood cells with a greater proportion of plasma than is normally found in blood. Practically, for first and superficial second degree burns of no more than 25 per cent body surface area, plasma or a plasma substitute is satisfactory. For all other burns, particularly those with considerable third degree destruction, whole blood is required.

In surveying a group of severely burned patients, we found that giving blood and dextran in a ratio of 1:2 was adequate to provide proper circulatory support and to prevent anemia.[7] It must be realized that in burns covering one-half or more of body surface, the calculated fluid volume, as determined by this formula, is prone to be greater than the patient actually needs. It is seldom wise to administer more than 10,000 cc. (4000 cc. colloid, 4000 cc. saline, 2000 cc. dextrose and water) during the first 24 hours. It is prudent to consider 50 per cent of body surface area damage as a *maximum* for substitution in the formula.

During the second 24 hours, usually one-half of the colloid and saline previously administered is needed. The metabolic requirement for water during this period is 2000 cc.

It must be realized that the formula for estimation of fluid requirements is not absolute and should be used only as a simple clinical guide. The type and quantity of fluid required are fundamentally dependent upon each patient's response to his injury, determined by the general condition of the patient, the hourly urinary output and the degree of hemoconcentration.

*General Condition of the Patient.* This is determined by a rapid history and physical examination, particular atten-

*Renal Function.* Studies of renal function in adequately treated patients with severe burns fail to reveal any evidence of renal damage, as measured by inulin clearance (glomerular filtration rate), para-aminohippurate clearance (effective renal plasma flow) or tubular function. ($Tm_{pah}$)[5] The hourly excretion of urine in the successfully treated patient is 30 to 50 cc or more. Renal failure is usually precipitated by complications such as inadequate or delayed treatment leading to shock, transfusion reaction, and severe sepsis, which are, for the most part, preventable

## Treatment

*First Aid.* First aid treatment of minor burns consists of relief of pain followed by cleansing and protection of the wound from further injury. The intensity of pain is variable and not necessarily related to the extent of injury. As a rule, third degree burns are less painful than second degree ones, probably because in the former sensory nerve endings have been destroyed. The use of codeine phosphate, 30 mg., or Demerol, 50 mg., hypodermically, will usually suffice to relieve the pain of this type of injury. The minor thermal injury may be treated by the open (exposure) method or by the closed (dressing) method. The former is usually preferable for burns in commonly exposed areas which are not subject to repeated trauma, such as the face and neck. For all other minor burns, the closed method is preferable in ambulatory patients because it protects the wound from both accidental trauma and pathogenic bacteria.

The burned area is first placed on a sterile drape. Then, under sterile precautions, with forceps and scissors, the wound is gently débrided, blisters are excised, and the bleb fluid, which is an excellent culture medium, is evacuated The wound should then be cleansed with a suitable detergent such as pHisoHex and saline solution. One layer of dry fine mesh gauze is then applied next to the wound, followed by an absorptive dressing and secured by an elasticized cotton bandage and adhesive tape. This makes a durable occlusive dressing which should remain in place for approximately 10 days.

*First and Superficial Second Degree Burns.* If a first degree burn involves a considerable area of the body, such as a sunburn, it may cause severe burning pain as well as systemic symptoms of nausea, vomiting, headache, malaise and, occasionally, fever. As a rule, the systemic manifestations subside within two or three days. Such patients are best treated by the exposure method and kept comfortable with small amounts of codeine. For prevention of severe sunburn, preparations containing sunscreens have been effective.

Minor superficial second degree burns are best treated in the manner described under First Aid. Such burns heal almost completely by the end of the second week. Most minor burns heal satisfactorily without antibiotic therapy unless invasive infection develops. Tetanus immunization is advisable by injection of tetanus antitoxin or by a booster dose of toxoid if the patient has been previously immunized. Before antitoxin is given, a skin test for sensitivity to horse serum is mandatory.

*Deep Second and Third Degree Burns.* This category encompasses the most severe group of burns. As with lesser burns, relief of pain takes precedence over other treatment. It should be remembered that in severely burned patients, shock may develop within two or three hours after injury, and any drug injected into the subcutaneous tissue will be poorly absorbed because of sluggish circulation. Under such circumstances, injection of morphine or other narcotic subcutaneously may have little effect, but repeated injections should be ordered cautiously because of the danger of morphine poisoning from rapid absorption of the drug upon relief of shock and improved circulation. For these reasons, slow intravenous injection is often the best method of administration of narcotics Furthermore, it has the distinct advantage of more rapid relief of pain. Restlessness, which is commonly associated with shock, is often mistaken for pain, and may be associated with hypoxia. This symptom is usually relieved upon relief

and vomiting (apparently from gastric atony and dilatation) frequently occur. This complication makes intensive oral therapy impractical. In all burn patients, fluids should be administered by mouth with caution to ascertain individual tolerance. As emphasized by Moyer, under such conditions large amounts of water may so dilute the body electrolytes as to induce water intoxication. To avoid this, he advocated use of a solution of 3 to 4 gm. of table salt and 1 to 2 gm. of bicarbonate of soda to one quart of water. The amount of fluid administered by mouth must be included as part of the total intake in estimating fluid requirements.

*Care of the Burn Wound.* Treatment of the burn wound must be postponed until fluid therapy has been instituted and shock controlled. The two most effective methods for treating the burn are the closed and the open (exposure) methods.

*Closed Method.* Interest in the closed method of treatment was revived in 1942 when emphasis was placed upon conversion of a contaminated to a clean wound and protection from reinoculation by application of an occlusive dressing.[8] Originally, a pressure dressing was thought to be beneficial in limiting wound edema formation; this has been shown not to be true. The closed method, however, utilizing a firm occlusive dressing, has wide applicability in the treatment of burns and is generally satisfactory.

Under aseptic conditions, gross dirt, bits of charred clothing and strips of devitalized skin are removed. Large blisters should all be débrided. The wound should be gently cleansed with a detergent such as pHisoHex and saline solution in order to achieve a surgically clean wound. Gentleness in handling tissues cannot be too strongly emphasized. Brush scrubbing not only produces pain but increases tissue damage and exudation.

After the wound has been cleansed, an initial dressing is applied consisting of a simple fine mesh gauze base covered with sterile sponges and an absorbent gauze. This is held in place firmly by elasticized cotton bandage and adhesive. If available, a standard layered cellulose burn pad, containing a layer of fine mesh gauze, several layers of absorbent cellulose, and a water repellent jacket, may be used. These sterile pads, a stock item in the armed services, are available in two sizes designed to fit an entire arm or leg and may be rapidly applied. We have used them extensively and found them most helpful.

Dressings should not be applied to burns on the head, neck or perineum. Not only do these areas heal better when left exposed, but it is also technically difficult to maintain a bandage over them. Contamination of the dressing with discharges of the nose and throat and anogenital areas further compounds the problem. Maintenance of compression of the neck by dressing may cause respiratory distress.

Burns of the hand require special care, since the burned fingers must be wrapped individually and the hand must be maintained in the functional position. Such injuries should be dressed within 5 to 7 days. If the full thickness of the skin has been destroyed, the slough should be débrided and skin grafting should be performed as soon as possible, usually by the tenth to fourteenth day, in order to secure early healing and maximal return of function. It is much easier to secure a full range of motion of the hand starting from the functional position than from any other.

Care must be taken to avoid a constricting point in applying dressings. Damage to nerves and blood vessels in this manner is one of the chief dangers of the dressing method. The initial dressing should not be changed for 10 days. Most patients with second and third degree burns may be expected to run a febrile course until such time as the wound becomes clean and free of dead tissue and skin is grafted. The temperature tends to become less spiking once the dead tissue is removed and a clean and granulating wound obtained. Superficial second degree burns will ordinarily heal within ten days to two

tion being focused upon the heart, lungs and extent of injury. If cardiac failure is detected, digitalization should be rapidly accomplished so that the patient will be able to cope with the cardiovascular load that he will have to assume. The pulse, temperature, respirations, and, when possible, blood pressure should be rapidly determined. The pulse volume and capillary flow in the nail beds are good indices of adequacy of circulation. A full, slow pulse, warm extremities and pink nail beds which fill rapidly after being blanched indicates adequate fluid replacement. Repeated evaluation of these indices from time to time is essential to the adequate treatment of the burn patient.

*Hourly Urinary Excretion.* Next to general evaluation of the patient, the most important single guide to adequacy of fluid replacement is the rate of urinary excretion. Since fluid shifts rapidly in the burned patient, the rate of urinary excretion should be determined hourly. This can be most accurately measured by use of a Foley type catheter in the bladder. Because of the size of the urethra in young children, a size 10 or 12 French catheter may have to be used. For adults, the optimal hourly rate is 30 to 50 cc., and for children approximately 20 cc. Excretion of 50 cc. of urine per hour means that the pressure and composition of blood perfusing the kidneys are satisfactory, that cardiac function is reasonably normal, and, by inference, that perfusion of other vital structures, such as the lungs, brain and liver, is probably satisfactory. If less than 25 cc. of urine is excreted each hour, more fluid must be administered. This will usually result in a satisfactory increase in urinary excretion. If it does not, rapid injection of 500 cc. of plasma or dextran within a period of one-half hour may indicate whether the decreased output is due to insufficient intake or to renal damage. If the existence of renal injury is established, only enough intravenous fluid should be given to maintain circulatory efficiency. Renal failure, even in severe burns, is almost completely preventable.

*Hemoconcentration.* The degree of hemoconcentration, as measured by the hematocrit or the hemoglobin level, reflects, to a limited extent, the diminishing plasma volume. Such determinations should be made every 4 to 6 hours during the first 48 hours. Individual values have little significance, but a rising hemoglobin level usually means that fluid therapy is inadequate, whereas a falling hemoglobin value indicates that edema is reabsorbing. Blood transfusion obviously results in a rise in the hemoglobin concentration. The use of whole blood as the primary colloid in replacement therapy will give rise to high hemoglobin or hematocrit values during the first 48 hours. In one patient in our experience the hemoglobin value rose to 29 gm. per 100 cc. Under such circumstances, the increased blood viscosity and sludging may predispose to the development of thrombosis, although clinical experience to date has given no real reason to fear this complication. For practical purposes, hematocrit values up to 65 per cent or a hemoglobin level up to 25 gm. per 100 cc. would seem to be safe. It must be realized that the hemoglobin (or hematocrit) value represents the concentration of red cells per 100 cc. of blood. It is common to find a high hemoglobin determination with a diminished circulating blood volume (decreased red cell mass). The use of adequate amounts of whole blood during the first two days will replace deficits of red cells caused by injury and help combat the anemia which frequently accompanies deep burns in later stages.

In an average adult with a burn in excess of 30 per cent of body surface area, we have found that 1500 cc. of whole blood given during the first few days after injury will, as a rule, adequately replace the losses of red cells incurred during the first week after injury.

In adults with burns up to 15 per cent of body surface area, oral administration of fluids is usually adequate. For those covering 20 per cent or more of surface area, however, especially if treatment is delayed and shock is present, nausea

and vomiting (apparently from gastric atony and dilatation) frequently occur. This complication makes intensive oral therapy impractical. In all burn patients, fluids should be administered by mouth with caution to ascertain individual tolerance. As emphasized by Moyer, under such conditions large amounts of water may so dilute the body electrolytes as to induce water intoxication. To avoid this, he advocated use of a solution of 3 to 4 gm. of table salt and 1 to 2 gm. of bicarbonate of soda to one quart of water. The amount of fluid administered by mouth must be included as part of the total intake in estimating fluid requirements.

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weeks. Treatment of third degree burns by a combination of surgical débridement and intermittent dressings will ordinarily result in a clean granulating wound within the third or fourth week, so that skin grafting may be accomplished.

Dressings subsequent to the initial one should consist of a single layer of fine mesh gauze lightly impregnated with a bland ointment and a sterile absorptive dressing. The ointment should melt readily at body temperature, should be preferably water soluble and bland, and should contain no antibiotics or other potent agents. The purpose of the ointment dressing is to allow adequate drainage of the wound and to prevent adherence of the dressing to the wound.

*Open Method.* The open (exposure) method, based upon the principle that a dry wound crust protects the body from invasive infection and promotes healing beneath it, is an acceptable method of treatment. Its proper application also provides satisfactory results. Following minimal débridement and cleansing of the burned area in the manner previously described, the patient is placed upon a clean bed covered by a cradle (no heat) and the wound is allowed to dry. The room temperature should be warm enough for the patient's comfort. Control of flies and other insects is essential. A dry, firm, brownish crust usually forms within the first two to four days. The patient so treated is comfortable, and the burned areas are not unduly sensitive to touch. When cracks appear, affording an avenue for entrance of organisms, the eschar on either side of the crack should be débrided a short distance and dressed daily with ointment-impregnated fine mesh gauze. This assures adequate surgical drainage and prevents further development of infection.

This method is not applicable to encircling burns of the trunk and legs since they cannot be adequately exposed continuously. Burns of the hand, like those about joints, are best treated by the closed method. If hand burns are not bandaged and splinted in the position of function because of edema, pain or scarring, restoration of normal function becomes much more difficult. In burns about joints, cracks are common, and immobilization is needed to promote healing. For treatment of burns combined with other injuries, such as compound fractures, the closed method should be employed following surgical débridement and alignment of the fracture. A plaster cast may be applied over the dressing. An exception to the above statement may be noted in the extensively burned patient, i.e., 50 to 60 per cent of body surface area, in whom hyperpyrexia becomes prominent if virtually the entire body is dressed. Therefore, it becomes necessary to expose a major part of the body surface in order to promote adequate heat loss. Under these circumstances, we have found it advisable to withhold the application of dressings to the trunk even though the trunk may be burned circumferentially. This procedure has avoided fatal hyperpyrexia in instances when previous experience would have led us to believe that it would have occurred had the patient been dressed.

***Treatment of Infection.*** Treatment of the infected burn is difficult. Whereas true invasive infection is no longer common, low grade infection is always associated with deeper burns, despite the use of potent antibiotics. To prevent or control infection in the burned patient, not only must growth of the organisms be controlled but the media in which they live must also be removed. The key to the control of infection lies in removing the burn slough as early as possible. As a rule, invasive infection can be prevented by administration of an appropriate antibiotic. On the other hand, organisms find a desirable medium for multiplying in the warm, moist environment of the pabulum of slough. The effectiveness of antibiotics acting in such an area is greatly reduced. Once the wound is free of slough, serious infection becomes rare and healing occurs rapidly.

*Prophylaxis.* It is helpful in the severely burned patient to attempt to prevent or delay the development of infection. For this purpose, penicillin and

streptomycin are commonly used in the usual dosage and are continued a minimum of 5 days. When the patient becomes septic, it is important that a wound culture be performed and appropriate antibiotic sensitivity tests done. On this basis, a selection of the appropriate antibiotic can be made and the treatment of infection carried out more intelligently. It is re-emphasized that the antibiotics, although helpful, will not solve the patient's basic infection problem. Until the dead tissue is removed, a clean granulating wound obtained and the patient's skin grafted, the infection problem will not be completely solved.

*Septicemia.* Septicemia may occur in the severely burned patient, particularly if there are significant undrained areas of infection as, for example, a collection of pus beneath a thick, heavy eschar. Blood cultures should be drawn frequently, planned to coincide with temperature spikes. Meticulousness in collection of blood culture samples must be observed. When widespread surface infection is common, false positive blood cultures are frequent. Treatment of septicemia demands surgical drainage of any undrained infected area combined with intense appropriate antibiotic therapy, often given intravenously. Blood transfusions are helpful. Once septicemia develops, the prognosis is guarded.

*Local Antibiotic Therapy.* Although in principle the local application of antibiotics to the burn wound would seem to have much to offer, in practice, this has not held true. We, as others, have used potent antibiotic agents locally in an attempt to decrease the wound flora and have been unable to produce any significant alteration in infection. Furthermore, increased bacterial resistance occurs. Local antibiotic therapy, therefore, is not recommended for the extensive burn.

*Tetanus Immunization.* It is advisable to administer 1500 to 3000 units of tetanus antitoxin to all patients with burns of more than minimal extent, after they have been skin tested for sensitivity to horse serum. If the patient has been previously immunized with tetanus toxoid, a booster dose of 0.5 to 1 cc. is indicated.

*Hormonal Therapy.* Indications for the use of ACTH and cortisone in the burned patient have not been clearly defined. Under the great stress imposed by a severe burn, conceivably a deficient cortical hormone utilization may exist, so that the patient might benefit from hormone therapy. Furthermore, administration of cortisone only during the first few days after injury may, by inhibition, diminish the ACTH discharge and thus possibly prevent overstimulation of the adrenal glands which may lead to adrenal hemorrhage and edema.

Determination of the 17-hydroxycorticosteroids in plasma following burn injury leads to the conclusion that such patients routinely develop quite high levels. Furthermore, the addition of cortisone to the treatment regimen does not appear to affect the patient's outcome significantly. Although the tissue requirements for this drug are unknown, it would not appear, in face of the strikingly high values observed postburn, that a deficiency of this substance exists. Nor would it appear that such patients suffer loss of adrenal function due to hemorrhage and edema. The contention that ACTH diminishes the requirements of the body for fluid after a thermal injury has not been confirmed.[9] At present, there seems to be insufficient justification for use of these hormones except on an investigational basis or when a clearly demonstrated deficiency exists.

*Use of Skin Homografts.* The use of skin homografts constitutes a life-saving maneuver in certain severely burned patients. Patients who have burns of the order of 30 to 60 per cent of body surface area, of which a significant amount is third degree, may survive the first three to four weeks of their injury, during which time their wounds become surgically clean and granulating, but they may be in such poor condition that general anesthesia followed by autografting is inadvisable. Under these circumstances, it has proved beneficial to secure skin homografts from a fresh cadaver or, in some instances, a member of the fam-

ily, applying these grafts to the wound to secure temporary wound healing. This procedure may be carried out in a dressing room without general anesthesia. Properly applied, from 60 to 80 per cent graft "take" can be expected. Used in this manner, homografts provide a temporarily healed wound and enable the patient to recover his body defenses, improve his nutrition, and become a better candidate for anesthesia and autografting. In our experience, such homografts are rejected in three weeks to three *months, usually about six weeks after* their application. Once the homografts are rejected, autografts are used to cover the defect.

*Skin Grafting.* Third degree burns with extensive cutaneous destruction require skin grafting. In many instances, this is the only possible way that satisfactory wound healing can be achieved. In principle, skin grafting is a means of closing an open wound. In practice, skin grafting should be well under way if not complete by the end of the third or fourth week, since early healing not only minimizes scarring and loss of function but also eliminates continued loss of protein Split thickness skin graft is applied as soon as a clean granulating bed is obtained. This means that the wound must be free of dead tissue, that granulation tissue must be healthy and free of infection. Furthermore, the patient should be in optimum condition for the operative procedure in terms of adequate *protein repletion and replacement of* hemoglobin deficits. Approximately one-quarter to one-half of the thickness of the skin is removed as a free graft, using a calibrated dermatome. This graft is then placed directly over the granulating wound and is immobilized. At the time of the first dressing following operation, usually 5 days later, one can anticipate getting approximately 90 to 95 per cent "take" of grafts.

In certain small well-circumscribed third degree burns, primary excision and grafting may be performed immediately after injury. Every effort should be made to close the wound at the earliest practicable date.

*Nutritional Therapy.* The importance of adequate nutrition in the severely burned patient can hardly be overemphasized. Good nutrition is of primary importance in determining whether or not the dead tissue can be removed from the patient's body and his wound prepared for skin grafting, and in determining whether the grafts will "take" in a high percentage or slough. The problem of resistance to infection is related to adequate nutrition as well, specifically with regard to the formation of gamma *globulin. Extensive clinical experience* points to the fact that with good nourishment the wounds heal more rapidly, function is recovered more readily, and patients leave the hospital more quickly than those receiving subnormal nutrition.

During the first 48 hours after severe burns, patients are frequently able to take only a few liquids by mouth, and nausea and vomiting are a common problem. Increasing oral feeding will depend upon recovery of normal gastrointestinal function. Ordinarily, by the third or fourth postburn day, a patient will tolerate milk satisfactorily. In an adult, a 1200-caloric, 60-gram protein diet is begun about the fifth day, prepared in a liquid feeding. Adequate vitamins and minerals are, of course, important. The protein and calories in the diet may be increased at intervals of every two or three days until a quantity is administered which will meet the *needs of the individual patient.* This may vary from 1 to 3 grams of protein per kg. of body weight per day and 40 to 60 calories per kg. of body weight per day, depending upon age, sex and weight. The chief advantage of a liquid feeding is the ease with which one can be certain that the patient will get the required nutritional therapy. Nausea, vomiting and diarrhea have occasionally been a problem in administering high levels of carbohydrate intake as a liquid feeding orally. This problem is minimized by careful stepwise increments in the diet to desired levels. As previously indicated, the catabolic phase of *protein metabolism* occurs during the first three weeks

following burn injury. During this period there is excessive loss of nitrogen. This loss is not preventable by adequate protein intake, but it may be minimized as evidenced by decreased weight loss and improved general condition. With the advent of the anabolic phase, at approximately 3 weeks postinjury, when the nitrogen balance turns to the positive side, protein losses are more rapidly regained under the dietary regimen outlined. Patients so treated commonly leave the hospital weighing as much as or more than they did at the time of injury.

### Mortality

Death from burns is influenced by the age of the patient and the extent of surface area involved. Using the probit analysis technique, Bull and Fisher prepared a table of anticipated mortality which emphasizes the frequently unrecognized gravity of extensive burns (Table 2).[10] Our experience agrees in general with that of Bull and Fisher. It is apparent that a burn involving 50 per cent of the body surface area of a 50-year-old patient will almost always be fatal. The mortality table is useful not only as a means of evaluating the mortality risk in the individual patient, but also as a means of evaluating methods of treatment in any given series of cases.

### Atomic Burns

Atomic burns may be of either the flash or the flame type. Flash burns caused by high intensity, short duration light exposure occur immediately after detonation. They may be first, second or third degree but are commonly superficial. Flame burns result from secondary fires following an atomic explosion. Although radiation injury was not considered a primary factor in mortality in the Hiroshima atomic explosion, experimental evidence strongly suggests that the mortality rate of a standard burn is greatly increased by addition of sublethal (100 r) doses of total body radiation.[11]

Acute radiation sickness results from exposure of the total body to radiation of 100 to 300 r or more. Exposure to 600 r or more is regularly fatal, and it is estimated that half of the people exposed to 400 r will die. Lesser amounts of radiation produce a syndrome characterized by a latent period lasting as long as two weeks, followed by loss of appetite, malaise, loss of hair, diarrhea and a tendency to bleeding. As the amount of radiation increases, the symptoms appear more quickly. Soon after moderate ex-

*Table 2.* **Grid of Approximate Mortality Probabilities for Various Combinations of Age and Area.**

| % Body Area Burned | Age–Years | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0–4 | 5–9 | 10–14 | 15–19 | 20–24 | 25–29 | 30–34 | 35–39 | 40–44 | 45–49 | 50–54 | 55–59 | 60–64 | 65–69 | 70–74 | 75–79 | 80–84 |
| 78 or more | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 73–77 | 9 | 9 | .9 | 9 | .9 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 68–72 | 9 | .9 | .9 | 9 | .9 | 9 | .9 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 63–67 | 8 | .8 | .8 | 8 | .9 | 9 | 9 | .9 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 58–62 | 7 | .7 | .7 | .7 | 8 | .8 | .8 | .9 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 53–57 | .6 | 6 | .6 | 6 | 7 | .7 | .8 | 8 | .9 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 48–52 | 5 | 5 | .5 | 5 | 6 | .6 | .7 | .7 | .8 | .9 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 43–47 | .4 | .4 | .4 | .4 | .4 | 5 | .5 | .6 | .7 | .8 | .9 | 1 | 1 | 1 | 1 | 1 | 1 |
| 38–42 | 3 | .3 | 3 | .3 | .3 | 4 | 4 | .5 | .6 | 7 | .9 | 9 | 1 | 1 | 1 | 1 | 1 |
| 33–37 | .2 | 2 | .2 | 2 | 2 | .3 | .3 | .4 | .5 | 6 | 8 | 9 | .9 | 1 | 1 | 1 | 1 |
| 28–32 | 1 | 1 | .1 | 1 | 2 | .2 | 2 | .3 | .4 | .5 | .6 | .8 | .9 | 1 | 1 | 1 | 1 |
| 23–27 | 1 | 1 | 1 | .1 | .1 | .1 | 1 | .2 | .2 | .3 | .4 | .6 | .8 | .9 | 1 | 1 | 1 |
| 18–22 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | .1 | .1 | .2 | 3 | .4 | .6 | .8 | 9 | 1 | 1 |
| 13–17 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | .1 | .2 | .3 | .4 | .6 | .7 | .8 | .9 |
| 8–12 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | .1 | .1 | .2 | .4 | .5 | .6 | .7 |
| 3–7 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | .2 | .3 | .4 | .5 |
| 0–2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | .1 | .1 | .2 | .3 |

(From Bull, J. P., and Fisher, A J: A study of mortality in a burns unit. A revised estimate. Ann Surg., *139*.269, 1954.)

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by hemoglobinuria, azotemia and acidosis. Normal circulatory homeostasis should be maintained until renal healing occurs and function returns. Attention is focused on fluid and electrolyte therapy with emphasis on restriction of intake to equal insensible and other losses. Overtreatment is a common hazard.

Deep electrical burns are best treated by surgical excision, if the patient's condition permits. Such burns are frequently circumscribed and, following excision, they may be closed by primary suture or skin grafting when necessary. This course avoids prolonged sloughing and infection, minimizes loss of function and hastens recovery.

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posure to radiation, the lymphocyte count drops precipitously. There is an initial increase in granulocytes followed by a sharp fall. Change in platelet count parallels that of the granulocytes. There is a drop of 1000 to 3000 per cu. mm. in the white blood cell count, which stabilizes for approximately one week, after which recovery gradually occurs. The erythrocyte count may drop to anemic levels during the first week, especially if exposure to radiation has been extensive. For these reasons the incidence of infection following radiation injury is increased.

Treatment of flash burns and radiation complications does not differ greatly from that of flame burns. Many flash burns, being profile in type, are amenable to the exposure method of treatment. The fluid and electrolyte requirements are determined in the same way as for patients with flame burns. Penicillin offers considerable protection against the effects of burns and sublethal radiation injury. Blood transfusions and supportive measures are also helpful.

### Respiratory Tract Burns

Burns of the respiratory tract may be extremely serious. Complications vary from mild edema of the nasal passages to pulmonary edema and rapid death. In any flame burn about the face, a respiratory injury should be suspected, and the nasal hair and nasopharynx should be examined for evidence of singeing or redness. Progressive evidence of respiratory distress, such as wheezing, stridor or cyanosis, is indication for immediate tracheotomy. Removal of tracheobronchial secretions is greatly facilitated by tracheotomy. Because of a tendency to pulmonary edema, fluids should be administered cautiously. Oxygen therapy may be necessary if cyanosis exists. The patient should be carefully observed at frequent intervals. The prognosis is guarded.

### CHEMICAL INJURY

In treatment of burns caused by alkali or acid, the material should be immediately washed off with copious amounts of water. Then a mild acid, such as acetic acid (vinegar), or a mild alkali, such as sodium bicarbonate, may be employed for neutralization. Further lavage is then carried out. An occlusive dressing is applied.

Magnesium burns rarely occur. They should never be washed immediately with water. The burned area should be painted with 1 per cent solution of copper sulfate and then lavaged with saline solution. Magnesium particles imbedded in the skin may be surgically removed if necessary.

Phosphorus burns should be flushed first with water and then with a solution of copper sulfate. Any particles of phosphorus should be removed with forceps. Larger burns may require prolonged soaking in a solution of sodium bicarbonate and frequent dressings until healed.

Chemical burns of the eye are a serious problem. Acid burns should be treated immediately by copious washing with water followed by sodium bicarbonate solution when available (0.5 per cent). Alkali burns of the eye should be washed also with water followed by a 1 per cent acetic acid solution. Such patients should be referred to an ophthalmologist promptly.

### ELECTRICAL INJURY

Electrical burns are usually serious injuries requiring prompt hospitalization. Death may ensue promptly from ventricular fibrillation or may follow injury of the respiratory center and asphyxia. In the latter type of injury, artificial respiration may be life-saving.

There are two types of local lesion: (1) a char, produced by an arc between the skin and the contact, and (2) destruction resulting from passage of current through tissue. If charring is extensive, excision of the destroyed tissue and subsequent skin grafting may be necessary. Skin and tendons are most seriously affected by electrical injuries, since they offer the greatest resistance to flow of current. Extensive destruction of tissue results in sloughing and extensive scarring. Passage of the current through the kidneys may cause renal injury, followed

attempted whenever possible, but if there is extensive tissue necrosis the area should be excised and grafted.

Pyogenic infections of the skin are especially prone to complicate systemic metabolic disorders. This is especially true of diabetes mellitus, Cushing's syndrome and neoplastic cachexia.

### CELLULITIS AND PHLEGMON

Cellulitis and phlegmon are nonsuppurative inflammations of the subcutaneous tissues, and as such require differentiation from the hemolytic streptococcus gangrene described elsewhere. Brawny edema, pain and tumefaction are constant features. Although central necrosis may result in suppuration, this is usually a later stage of the nonsuppurative initial process.

Both aerobic and anaerobic bacteria may cause cellulitis. The cellulitis associated with infection produced by anaerobic bacteria has distinguishing characteristics and is discussed separately (see Gas Gangrene and Anaerobic Cellulitis). The most usual etiologic organism in cellulitis is the hemolytic streptococcus Erysipelas and surgical scarlet fever may accompany the infection.

Antibiotic therapy with rest, heat and splints should be combined with vigilant anticipation of deep or superficial fluctuation Failure of the inflammatory swelling to respond typically after 48 to 72 hours of antibiotic therapy should suggest deep suppuration and may warrant exploratory aspiration or incision. Early drainage of recognized foci of suppuration is indicated. Delayed closure of these incisions is occasionally desirable and practical.

### LYMPHANGITIS AND LYMPHADENITIS

Lymphangitis is inflammation of lymphatic pathways. It may be tubular or reticular. Tubular lymphangitis results from inflammation of the main cutaneous channel in the longitudinal axis of an extremity. Reticular lymphangitis develops when the collecting lymphatics of the skin are involved. Most lymphangitis is visible as an erythematous streaking of the skin. This is especially true in hemolytic streptococcic infections. Occasionally, lymphangitis is more readily identified by palpation, a procedure considerably simplified by previous oiling of the skin. Recognition of lymphangitis is important because its presence indicates invasive infection and faulty inflammatory localization.

Lymphadenitis is the inflammatory swelling of lymph nodes. When palpably enlarged nodes are tender, there is a strong presumption of recent rapid swelling in consequence of invasive infection. Palpable nodes that are not tender do not have this correlation with invasive infection. When lymph nodes are both tender and fixed to surrounding soft parts, suppuration is usually present. Simple fixation without tenderness is more suggestive of tuberculosis or lymphoma.

### ERYSIPELAS

*Definition.* The classic lesion of erysipelas is the "butterfly" erythema centering around the nose and extending onto both cheeks. Better understanding of the identity of streptococcal erythrogenic toxins has led to broadened designation of most erythemas in association with hemolytic streptococcal infections as erysipelas.

*Etiology.* Erythrogenic, or scarlatinal, toxin is produced in variable quantity by many strains of hemolytic streptococci. An apparently identical toxin has also been isolated from certain strains of staphylococci. Basic immunity to scarlatinal toxin is also widely variable, hence the development of cutaneous erythema is an inconstant manifestation of streptococcal and occasionally staphylococcal infection.

*Clinical Course.* Minor skin abrasions, rhagades, herpetic lesions and seborrheic dermatitis predispose to coccal infections of the skin. Occasionally, the break in the integument is too small to permit recognition. Erysipelas usually occurs in elderly people with trophic changes of the skin. The involved cutis is edematous and reddened with a palpably raised border. The lesion is hot, tender and painful. Systemic manifestations may be

*Chapter 11*

# Infections

*By Champ Lyons*

### IMPETIGO, FURUNCLES AND CARBUNCLES

An abscess is a circumscribed collection of pus in any part of the body. The terms "furuncle," "boil" and "carbuncle" are applied variously in the designation of particular types of abscesses found in relation to the integument. It is with these more superficial infections that this discussion is concerned.

Furuncles occur as abscesses in sweat glands or hair follicles. The premonitory symptom is frequently pruritus, and the patient believes he has suffered an insect bite. The infection may involve layers other than the skin. Infection of hair follicles is designated as folliculitis.

When a collection of pus lies within the subcutaneous tissue below the outer layers of the integument, it is usually referred to as a subcutaneous abscess or as a boil. Abscess formation beneath the corium of the skin is known as subepithelial abscess. Impetigo designates a series of intra-epithelial abscesses.

"Carbuncle" refers to a particular type of extension of a furuncle into the subcutaneous tissues. The nape of the neck, the dorsum of the trunk, the hands and digits and the hirsute portions of the chest and abdomen are especially apt to be involved. A carbuncle is a multilocular abscess with individual compartments being maintained through persistence of fascial attachments to the skin. As the numerous component locules rupture separately, individual fistulas appear.

In most abscesses the pyogenic cocci, usually staphylococci, are etiologic. It is not uncommon for secondary gram-negative bacilli to be found coincidentally.

The course of a furuncle is often self-limited and may require no specific therapy. Exception to this general rule is made especially when the furuncle is located in the so-called "dangerous triangle" of the nasolabial area of the face. The hazard in this location is that of septic phlebitis with intracranial extension along the nasal veins to the cavernous sinus. Similar dangerous areas overlie the sites of the occipital, mastoid and frontal emissary veins. The possibility of septic phlebitis under these circumstances warrants nonsurgical management and the routine use of antibiotics selected on the basis of sensitivity tests. Once indicated, no course of drug therapy should be of less than five days' duration.

Treatment of abscesses in regions other than the face is usually incision and drainage. Concomitant antibiotic therapy permits violation of the inflammatory barrier for more adequate drainage and expedites rehabilitation. As a general principle, early drainage of accessible pus is preferable to expectant treatment with drugs alone. Recurrent minor infections, such as impetigo, respond well to cleanliness and systemic antibiotic therapy.

Treatment of carbuncle differs from that of simple abscess in that every effort is made to avoid incision. Surgical drainage of a carbuncle demands wide undercutting of the skin flaps in order to exteriorize all compartments of the abscess. Slough of the under-cut skin is often a consequence. It also happens frequently that antibiotic therapy results in complete or almost complete resolution of the inflammatory process. A surgical approach to carbuncles is adopted only after a trial of drug treatment. Evacuation of a single abscess cavity is

attempted whenever possible, but if there is extensive tissue necrosis the area should be excised and grafted.

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severe and suggest invasive extension to the lymphatics or blood stream.

An especial type of erysipelas recurrently involves lymphedematous extremities with persistent exacerbation of the swelling. It is now established that each recurrence represents a new infection of a particularly vulnerable area. Inability to isolate the streptococci from these inflamed extremities has been explained by experimental demonstration of the erysipelas as a late toxigenic consequence of host destruction of an initially invasive streptococcus. Macerating lesions due to epidermophytosis are frequently present as a portal of entry, and prevention of recurrent erysipelas depends upon control of the epidermophytosis. Some success in changing macerating lesions to scaly lesions has attended lumbar sympathectomy in selected cases without previous vein ligation.

*Treatment.* Penicillin will usually terminate the progress of the invasive infection, but the erythema tends to disappear more slowly. Desquamation of the outer layers of the skin then follows. Recurrences may be prevented by treatment of predisposing skin lesions.

#### ERYSIPELOID

Erysipeloid, or "diamond erysipelas," occurs as a type of cutaneous cellulitis in man The causative agent is *Erysipelothrix rhusiopathiae,* an organism responsible for a disease of hogs known as "swine erysipelas." Erysipeloid is to be differentiated from erysipelas due to the hemolytic streptococcus. The causative Erysipelothrix is a slender, gram-positive rod which tends to form filaments and long chains of bacilli when cultured on serum agar at incubator temperature. Identification of the organisms in the local lesion demands biopsy and culture of the biopsy specimen. On rare occasions bacteremic forms of the disease will permit identification of the organism in blood cultures.

The disease is ordinarily contracted after contamination of a cutaneous abrasion during the handling of fish, shellfish, meat or poultry. Two to seven days later a painful area of edema and cyanotic erythema develops at the site of infection. There is a sharply elevated border to the area of cellulitis. Following the initial lesion, relapses are common and lesions may appear elsewhere on the body. Fever and arthritis suggest that the rare and acute bacteremic form of the disease is present.

Usually the disease is self-limited and symptoms abate after about three weeks. Penicillin therapy is specific in most cases, but its effect is less rapidly apparent than in streptococcal erysipelas.

#### GAS GANGRENE AND ANAEROBIC CELLULITIS

Under military conditions there is often unavoidable delay between serious injury and adequate initial surgical care. Prevention of these grave infections, saving of life and salvage of limbs are obligations dictating that the time lag between wounding and surgical treatment must be minimal.

*Definitions.* The clostridia are responsible for three varieties of wound infection: gas abscess, anaerobic cellulitis and clostridial myositis. Additionally, clostridia occur as wound contaminants in the absence of clinical signs of infection or toxemia. It follows that bacteriologic demonstration of these organisms in a wound is not alone sufficient basis for decisions concerning treatment. It is still not common knowledge that gas in tissue planes, foul odor and gram-positive rods on smear may co-exist in a relatively benign infection.

*Etiology.* The pathogenic clostridia are characterized by an ability to produce potent exotoxins. These toxins may be neurotoxins, as in the case of *Clostridium tetani* and *C. botulinum,* or histotoxins. The histotoxic clostridia are, traditionally, considered to be *perfringens, novyi, septicum, edematiens, histolyticum* and *bifermentans.* Recent evidence that the important histotoxins are lytic enzymes suggests that protease production by *C. sporogenes* should justify its inclusion among the histotoxic clostridia as well. Gas production may be a consequence of proteolysis or of saccharolysis. Many clostridia are solely saccharolytic.

The clostridia are ubiquitous and may

be found in soil, dust or feces. The vegetative forms are bacillary and gram-positive. Spore formation is only exceptionally seen in wounds and is rarely so typical as to permit species identification on the basis of spore morphology alone. Many of the clostridia are sufficiently fastidious in their cultural requirements as to defy culture in routine media or to make difficult demonstration of toxigenicity.

*Pathogenesis.* The locally destructive action of histotoxins upon tissues is clearly comprehensible in terms of enzymatic digestion. *Clostridium perfringens* alone produces five such enzymes: lecithinase, hemolysin, collagenase, hyaluronidase and desoxyribonuclease. The foul odor is a consequence of anaerobic proteolysis with formation of intermediary amines and amides.

Although the lecithinase, or alpha toxin, is lethal on intravenous injection experimentally, there is no evidence to support the existence of such diffuse toxemia with alpha toxin during the course of the clinical disease. All studies support rapid local fixation of these enzymes at or near their site of production. The fact that antitoxin is little, if at all, effective whenever toxemia and residuals of devitalized tissue coexist is further evidence against a true toxinemia. Intravascular hemolysis with the bronzing of deep jaundice occurs only during the course of clostridial bacteremia. Two possibilities have been suggested in explanation of the lethal outcome of untreated cases. It has been suggested that toxic factors derived from tissue breakdown, especially adenine derivatives, may be responsible. Most clinicians favor the opinion that severe local edema is responsible for lethal shifts in fluid and electrolytes.

*Clinical Course of Gas Abscess and Anaerobic Cellulitis.* These infections usually become apparent 2 to 3 days after injury. There is no pain or toxemia, but gas and foul odor are present. Gas abscess is the usual consequence of suppurative liquefaction of a dead space hematoma. More frequently, the clostridia multiply in devitalized tissue and the infection spreads along fascial planes. The wound margins are always tender and occasionally jaundiced and erythematous coincidentally to give the typical lesion of "bronze erysipelas." Surgical exploration of the wound is almost invariably necessary to differentiate anaerobic cellulitis from clostridial myositis. In both infections there is necrotic tissue in the wound, but in anaerobic cellulitis removal of the slough reveals living muscle which bleeds when cut. The infection may extend along fascial planes and extensive fasciotomy is necessary for proper inspection of the wound. Necrotic fascia must be excised. The fasciotomy and excision of necrotic tissue necessary for inspection of the wound requires only saline irrigation to complete surgical management of anaerobic cellulitis.

*Clinical Course of Clostridial Myositis.* Military surgeons in the Mediterranean Theater during World War II recognized two clinical types of clostridial myositis: the dry, emphysematous type and the wet type. *Clostridium perfringens (welchii)* predominated in the dry type.

In the *dry type of infection,* the most important initial symptom is pain in a previously comfortable wound. Apprehension and tachycardia out of proportion to fever precede hypotension and ultimate delirium. Anemia is almost invariably present. Odor, described as a "meat market smell" for true Welch bacillus infection, and exudation are not characteristic. Crepitus of the wound is almost always present.

In the *wet type of infection,* the most important initial symptom is a sense of heaviness in a previously comfortable wound. Apathy, tachycardia out of proportion to fever, and hypotension appear early. Oligemia and hemoconcentration are characteristic. Gas formation is minimal and inconstant, but pronounced swelling of the affected extremity and profuse serous drainage identify the gravity of the infection.

It is axiomatic that suspicion of the onset of clostridial myositis demands operative exploration of the wound as an

urgent emergency. The fasciotomy for exposure permits identification of avascular muscle, but experience is necessary to differentiate the serosanguineous ooze of edematous muscle from the bleeding of living muscle. Amputation of the infected extremity is the usual method of treatment, but occasionally an extremity may be saved by limiting excision to an involved muscle group. Treatment with gas gangrene antitoxin gives equivocal results and any real value is doubtful. A survival rate of 75 per cent is to be expected when adequate excision of infected muscle is done, but no case has survived when treated only with antitoxin. Unlike antitoxin, antibiotics are established as essential adjuvants of surgical treatment. Penicillin in dosage up to 12 million units daily by the intravenous route and the tetracycline compounds in usual dosage are the drugs of choice.

***Prophylaxis of Clostridial Wound Infections.*** There is no evidence that prophylactic gas gangrene antitoxin has merit. Recently, gas gangrene toxoids have shown promise in animal experiments, but these cannot be recommended until clinical trial has been reported.

Effective prophylaxis for clostridial infections consists in adequate initial surgical treatment of wounds within the modern concepts of débridement. The wounds should then be left open for 3 to 5 days. Later closure of these wounds as a secondary procedure follows the clinical demonstration that the wound is clean.

### HEMOLYTIC STREPTOCOCCUS GANGRENE

***Definition.*** Hemolytic streptococcus gangrene is also known as gangrenous erysipelas or suppurative fasciitis. It is a phlegmonous infection of the soft parts characterized by extensive subcutaneous necrosis and secondary cutaneous gangrene. There is usually severe erythema or frank erysipelas. It is to be distinguished from bronze erysipelas of anaerobic cellulitis with putrid pus and gas.

***Pathogenesis.*** Arteriosclerotic peripheral vascular disease favors this pattern of streptococcal infection. In the lower extremity the invading organism frequently enters through a break in the integument due to fungous infection. Sites of hypodermic injection, especially in addicts, are often etiologic. Urinary extravasation, excoriations due to fungus, eczema or maceration may favor perineal infection. Elsewhere scratches and pinpricks are important. Occasionally an especially devastating infection may follow a compound fracture or may occur at the site of introduction of a Kirschner wire or Steinmann pin.

This infection extends along fascial planes as a suppurative fasciitis. The fascia appears to dissolve, leaving muscle groups exposed as in an anatomic dissection. Blood vessels persist as thin strands within the abscess cavity and ultimately become thrombosed. Vascular thrombosis is followed by vesicle formation and slough of the representative cutaneous segment.

***Clinical Course.*** The clinical course is dramatic. The infection begins abruptly and may be ushered in with a chill. Within 12 to 24 hours the affected part is swollen, painful, and either erythematous or erysipelatous. The immediate diagnosis is usually cellulitis or phlegmon. Lymphangitis and regional lymph node involvement are not usually features of the early infection. Prostration is severe and tachycardia is out of proportion to the fever, which is rarely more than 101° F. As the infection progresses, the patient becomes apathetic and the lesion may become less painful or numb. The first signs of cutaneous gangrene appear in the untreated patient on the third to fifth day of the disease. "Black blisters," or vesicles filled with hemorrhagic exudate, overlying patches of cutaneous gangrene constitute the older pathognomonic sign of the disease. Necrosis of the skin with separation and slough follow, and the fascial plane abscess drains inadequately through these sinuses.

Potent antistreptococcal therapy, especially penicillin, has considerably modified the course of this once frequently fatal disease. Cutaneous gangrene is no

longer the pathognomonic sign of the disease. The diagnosis should be made on the basis of *residual foci of edema along the fascial planes* in an otherwise subsiding infection. The development of cutaneous gangrene implies delayed diagnosis.

*Treatment.* The first appearance of the infection as erythematous cellulitis justifies antibiotic therapy and management of diabetes if present. As soon as fascial plane involvement is suspected or defined by persistent edema, surgical drainage should be accomplished by a planned fasciotomy incision opening the entire length of the involved fascial plane. Attempts to avoid these long incisions by intensifying drug therapy and making stab wounds have been followed by progressive fascial slough. The wounds are dressed with fine-mesh gauze using gentle pressure. The wound should be left undisturbed after drainage in anticipation of early secondary suture. It is practical to drain residual abscesses and close clean portions of the wound at the same sitting. A similar program of management is applicable for the patient with established cutaneous gangrene or draining sinuses. In such instances, split thickness skin grafts may be done at the time of secondary closure. Unsightly scars may require later plastic revision solely for cosmetic reasons.

### SYNERGISTIC GANGRENE

*Definition.* Synergistic gangrene is also known as postoperative cutaneous gangrene or progressive postoperative bacterial synergistic gangrene. It is a carbuncular type of anaerobic cellulitis developing about 5 to 12 days after primary suture of a contaminated wound of the chest or abdomen. There is a purulent discharge from the suture site, purplish cyanosis and edema of the wound margins and a wide peripheral zone of bright and painful erythema.

*Etiology.* Synergistic gangrene must be differentiated from other less specific types of anaerobic cellulitis of postoperative wounds. By definition, this term "synergistic gangrene" is restricted to a postoperative wound infection demonstrated to have a pure culture of microaerophilic nonhemolytic streptococcus in the periphery of the lesion and a mixture of these streptococci and aerobic hemolytic *Micrococcus pyogenes* var. *aureus* in the central area of cutaneous gangrene. Mixtures of these two organisms reproduce the lesion when injected into animals. In the differential diagnosis, a search should be made for amebae to exclude cutaneous gangrene due to amebic infestation of the skin and subcutaneous tissues.

*Pathogenesis.* The infection has most frequently followed drainage of peritoneal abscesses. It has also occurred around retention sutures in a colostomy wound and after thoracentesis for putrid empyema. There is reason to believe that a technical error in wound management is important in the pathogenesis of this and similar postoperative anaerobic wound infections. It is now generally agreed that it is preferable not to close the skin and subcutaneous fat in contaminated wounds of the abdominal wall, and that aspiration of putrid empyematous pus is an indication for open thoracotomy through the site of thoracentesis.

*Clinical Course.* The course of this infection is singularly free from fever or toxemia. The distinctive features are pain and rapid progression of the infection. Within a few days of the first onset of pain and erythema of the wound, a wide area is involved. The spreading peripheral erythema encloses a middle zone of cyanotic skin and a central zone of "suede leather" cutaneous gangrene. The central zone gradually liquefies and sloughs out down to a base of friable granulation tissue. Hemorrhage is the chief complication to be anticipated. In addition, the patient's morale deteriorates seriously as a consequence of the extreme pain and visible progression of an uncontrolled infection.

*Treatment.* Before the advent of penicillin, considerable progress in control of this infection was made by wide excision of the skin and subcutaneous fat down to, but not including, the deep fascia. The incision was placed approxi-

urgent emergency. The fasciotomy for exposure permits identification of avascular muscle, but experience is necessary to differentiate the serosanguineous ooze of edematous muscle from the bleeding of living muscle. Amputation of the infected extremity is the usual method of treatment, but occasionally an extremity may be saved by limiting excision to an involved muscle group. Treatment with gas gangrene antitoxin gives equivocal results and any real value is doubtful. A survival rate of 75 per cent is to be expected when adequate excision of infected muscle is done, but no case has survived when treated only with antitoxin Unlike antitoxin, antibiotics are established as essential adjuvants of surgical treatment. Penicillin in dosage up to 12 million units daily by the intravenous route and the tetracycline compounds in usual dosage are the drugs of choice.

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complications are those of local extension along fascial planes with resultant abscess formation. Concomitant involvement of major vascular sheaths leads to serious hemorrhage from arterial erosion or to septic phlebitis with pulmonary infarction, pulmonary abscess or endocarditis.

*Differential Diagnosis.* Comparable cutaneous bridging and epithelial sinuses may be seen in suppurative hydradenitis. Superficial gumma may be distinguished by the characteristically offensive odor, absence of peripheral induration and positive serologic reaction.

*Treatment.* For the established ulcer, Meleney originally reported successful healing by a protracted regimen of meticulous local débridement in conjunction with topical application of activated zinc peroxide (Z.P.O., medicinal grade). The zinc peroxide is activated by heating to 140° C. for 4 hours in a dry heat sterilizer. The ulcer is irrigated free of exudate and packed with fine-mesh gauze saturated in a freshly prepared suspension of 10 per cent zinc peroxide in sterile distilled water. It is essential that all crevices of the ulcer be brought into contact with the dressing. Daily dressings are necessary. This treatment was designed to provide an excess of oxygen to discourage the anaerobic growth of the etiologic streptococcus A major handicap is the frequency of "caking" of particles of zinc peroxide in the depths of sinuses Although still advocated by Meleney, the method is not widely used today.

The more usual treatment of the infection emphasizes systemic treatment with an appropriately selected antibiotic, usually penicillin It is usually necessary to open sinuses, but skin need not be sacrificed. As soon as the wound appears clean, denuded areas should be grafted with skin. Meleney advocates pinch grafts for this purpose, but postage stamp grafts have proved equally practical.

### ANTHRAX

*Definition.* Anthrax is an acute infectious disease of domesticated animals, especially sheep, cattle, horses and swine. Man becomes infected by direct transmission or by contact with hides or hair. The systemic form of the infection, "woolsorter's disease," is characterized by pulmonary involvement and is apparently of infrequent occurrence at present. The predominant clinical pattern of anthrax is a cutaneous lesion, commonly known as the "malignant pustule," characterized by a blackish central eschar and a variable degree of edema.

*Etiology.* The anthrax bacillus is aerobic, gram-positive and spore-forming. The disease is thought to be endemic in the United States in southeastern South Dakota, northwestern Nebraska, the Texas Gulf Coast and the Mississippi Delta area. Infection of man is usually accidental.

*Clinical Course.* The cutaneous lesion in man has the initial appearance of a severe carbuncle. A distinguishing feature of this lesion is the early development of a central eschar surrounded by a border of violaceous cellulitis. Infections of the head, face and neck are further characterized by extensive edema and large serosanguineous bullae.

The severity of the infection varies in accordance with the site of the ulceration. Lesions of the head and neck are associated with septic phlebitis, intracranial extension and bacteremia. Lesions of the trunk or extremities are much more apt to remain localized and recovery may be spontaneous with healing of the ulcer slowly after slough of the central core of necrotic tissue.

The diagnosis is readily established by identification of predominant gram-positive rods in the serum of the bleb surrounding the eschar.

The treatment of choice is penicillin in fairly large doses. Immune sera are not necessary and surgical intervention for the acute lesion is ill-advised.

### TULAREMIA

*Definition.* Tularemia occurs in man as a sporadic disease and is usually the result of accidental inoculation, most frequently during the dressing of wild rabbits. Systemic tularemia is an acute

mately 5 cm beyond the zone of bright red erythema and the wound was dressed with a 1 per cent solution of Formalin or zinc peroxide. The ultimate defect was covered by skin grafting.

In 1941, penicillin was shown to be effective in the treatment of the established infection More recently, of course, prompt removal of sutures from an inflamed wound and early institution of penicillin therapy have controlled such infections in their incipiency. The prognosis of synergistic gangrene is now optimistic. Indeed, it seems likely that future cases will develop only where overconfidence in antibacterial agents leads to premature closure under tension of contaminated wounds or reluctant removal of sutures in an inflamed abdominal wound.

### CHRONIC UNDERMINING ULCER

***Definition.*** Chronic undermining ulcer was described and clarified by Meleney and is often designated as Meleney's ulcer. It is also known as chronic burrowing ulcer and phagedenic ulcer. The clinical appearance is that of a *slowly* progressive infection of the subcutaneous fat associated with ulceration of the overlying skin. Cutaneous gangrene is characteristically absent, but the rolled edges of the undermined skin may show cyanotic discoloration. The periphery of the lesion is indurated, erythematous and exquisitely tender. The infection may be protracted and last for months or years.

***Etiology.*** The causative organism is a micro-aerophilic hemolytic streptococcus. Cultural demonstration of this organism demands several precautions. Cultures must be taken from a site well under the undermined skin edge in order to avoid confusing overgrowth by the polymicrobial flora of the wound exudate in the central portion of the ulcer. Anaerobic cultures, preferably on a blood agar plate, are essential for primary isolation. In most instances the organism is hemolytic and belongs to Lancefield's group A of the beta hemolytic streptococci. Occasionally the streptococcus belongs to groups other than A, usually Lancefield's groups C or G. In these latter groups there is the possibility of nonhemolytic variants. Hence, if no hemolytic colonies are demonstrable on culture of a clinically typical lesion, the nonhemolytic colonies should be subcultured for grouping by extraction and precipitation with group-specific carbohydrate antiserums.

***Pathogenesis.*** Most of these ulcers begin as an inadequately or incompletely treated infection. The initial lesion may be minor folliculitis, a lymph node abscess or acute cellulitis with or without erysipelas. In one instance a number of characteristic ulcers developed as a late complication of bacteremia from pelvic cellulitis. It is often impossible to escape the conclusion that the ultimately identified micro-aerophilic organism is merely a mutant of an initially aerobic pathogen.

***Clinical Course.*** The lesion begins insidiously and is slowly progressive during a period of weeks or months. As the subcutaneous fat melts away, the overlying skin curls inward and the ulcer base becomes grossly suppurative. The undermining is frequently extensive and areas of necrosis in the skin and ultimate sinuses at a distance from the ulcer may develop. Epithelial strands and undermined bridges are characteristic. The actively advancing and indurated edge of the infection is characterized by erythema and tenderness. The pain is of varying severity but usually intractable. A low grade spiking fever is usually noted, but rises up to 103° F. may occur. Although the lesion tends for the most part to be confined to the subcutaneous fat, it is not unusual for it to spread along fascial planes with septic dissolution of the connective tissue. Lesions on the lower part of the abdomen are especially prone to burrow into the pelvis and point in the perineum. Occasional cases may heal spontaneously but this is apparently uncommon. More usually there is progressive erosion with increasing pain and debility demanding surgical treatment. The intractable pain predisposes to loss of morale and emotional instability. The most important surgical

costal fistula are present. Profound anemia, malaise and pronounced leukocytosis appear before pain and fever are severe.

*Abdominal actinomycosis* is usually apparent as a late or retarded complication of appendicitis, ulcerative ileocecal disease, or abdominal injury. The diagnosis is usually first suggested by fistula formation. In addition to severe anemia and leukocytosis, pain is occasionally severe. Secondary infection is frequent and systemic symptoms, especially emaciation, are common.

In the neglected patient metastatic foci develop in the vertebrae, lungs, liver and kidney with occasional cutaneous abscesses. Extreme chronicity and wasting are features of the infection.

***Treatment.*** Election of a program of treatment is influenced by the differential diagnosis of clinical actinomycosis and nocardiosis on the basis of identification of the pathogen Nocardiosis is a more benign form of the disease and responds well to conservative drainage of abscesses and selective antibiotic therapy. In general, the Wolff-Israel bacillus is sensitive to sulfonamides and penicillin, and the streptothrix organisms of nocardiosis are sensitive to tetracycline compounds and to streptomycin. Sensitivity tests are mandatory for final adoption of the antibacterial therapy.

The necessary surgical excision of tissue destroyed by *Actinomyces bovis* cannot be undertaken safely without extensive preoperative preparation of the patient. This is best accomplished by repeated transfusions, forced feeding and 10 to 12 days of specific antibacterial therapy. The inherent vascularity of the granulomatous lesion requires generous blood replacement during the surgical operation. True actinomycosis also requires that antibiotics be continued for 6 to 12 weeks after healing is apparently complete.

Meticulous management of these infections leads to permanent arrest of the disease. Recurrences are common when residual areas of necrotic tissue are not removed.

### BLASTOMYCOSIS

***Definition.*** Blastomycosis on the North American continent is due to infection with *Blastomyces dermatitidis,* and the resultant lesion is a chronic granulomatous infection of the skin and internal organs. Another fungus, *Blastomyces brasiliensis,* is indigenous to South America and produces primary papillomatous granulomas of the buccal mucosa.

***Etiology.*** *Blastomyces dermatitidis* has not been recovered except from clinical sources and then only in the United States and Canada. Presumably it exists in nature and contaminates wounds from some natural source, because transmissibility from man to man does not occur. The organisms are readily identified as large spherical spores with budding forms and a birefractive envelope. Special stains, such as the periodic acid shift, facilitate identification. The organism grows well on all laboratory media at either room or incubator temperature.

***Clinical Course.*** The disease may be discovered incidentally in the course of examination of pus from chronic foci of suppuration, especially bone abscesses. More usually, infection starts as a papulopustule of the nose, exposed portions of the extremities, or perineal area. The more advanced primary lesion has a granulating base with peripheral miliary abscesses and often a verrucous edge. Metastases occur earliest and most frequently to the lungs as multiple foci of granulomatous abscess not unlike miliary tuberculosis. Bacteremic spread is usually secondary to pulmonary lesions and further abscesses then develop in the ribs and vertebrae, the brain, and the subcutaneous tissues. The subcutaneous lesions are gummatous and there is a predilection for the proximal head of the gastrocnemius muscles. Spontaneous rupture of gummatous abscesses yields an extremely bloody pus.

The diagnosis depends upon demonstration of the organisms, but some help is afforded by skin and complement fixation tests.

***Treatment.*** Treatment is often unsuc-

infectious disease of moderate severity with predominant pulmonary involvement. In about 10 per cent of human infections, the first manifestation of the disease is an ulceration with massive regional lymphadenopathy.

***Etiology and Pathogenesis.*** The causative organism is the extremely pleomorphic *Pasteurella tularensis*. The reservoir of infection is in wild mammals and a wide variety of insect hosts are carriers. Bacteriologic identification requires special techniques and the contagiousness of the material presents special problems for laboratory personnel.

***Clinical Course.*** The onset of systemic tularemia is characterized by transient initial bacteremia and early signs of focal pneumonitis. The bacteremia is of variable intensity and severity, but does not usually persist more than a week. Death may occur as early as the fourth day or as late as the twelfth day from the onset of symptoms

Surgically important tularemia is characterized by the development of an initial papule at the site of inoculation of the skin or mucous membranes The papule becomes edematous and ulcerates, leaving a necrotic base. The regional lymphatic pathways become visibly and palpably enlarged. Tributary lymph nodes are massively involved with bubo formation It is an important differential point that these nodes are not apparent in the absence of a demonstrable primary lesion

The diagnosis is confirmed by demonstration of agglutinating and complement-fixing antibodies after the second week of the disease Earlier confirmation of the diagnosis is frequently possible with a skin test utilizing a suspension of the killed bacteria and producing a tuberculin type of skin reaction when positive.

Streptomycin has proved strikingly effective in the cure of this infection. Surgical drainage of the bubos is not necessary.

### ACTINOMYCOSIS AND NOCARDIOSIS

***Definition.*** Considerable confusion exists in identification of these infections because of botanic heterogeneity in the bacteriologic classification of actinomycetes. The clinical problem has been resolved through identification of two types of infections: actinomycosis and nocardiosis. Both are characterized as chronic granulomatous suppurations with predominance of abscesses, fistulas and excessive hemorrhage at the time of surgical drainage.

***Etiology.*** Clinical actinomycosis is a mixed infection wherein the ray fungus of Wolff-Israel, *Actinomyces bovis*, is identified. This organism is gram-positive, frequently acid-fast, and anaerobic. Its most certain identification lies in recognition of the ray fungus cluster characteristic of the "sulfur granule." These granules are most easily found in the pus of undrained abscesses or in biopsies of the pyogenic membrane of fistulous tracts. Mycelial forms result on culture and "sulfur granules" occur only in clinical infections.

Nocardiosis results from infection with streptothrix organisms of the actinomycetes. True "sulfur granules" do not occur, but particles composed of tangled masses of mycelial threads and fibrin are recognizable in pus. The organisms may be micro-aerophilic or aerobic and yield an abundance of mycelial forms on culture. Pathogenicity of these organisms is extremely variable and they may be present as secondary invaders in various types of wound suppuration.

***Clinical Course.*** The Wolff-Israel organisms are of limited invasiveness and actinomycosis is usually secondary in the course of ulcerative or traumatic lesions. Three clinical patterns of the disease are recognized:

*Cervicofacial actinomycosis* constitutes about half the clinical incidence of the disease. Dental sepsis permits soft parts invasion. Ligneous, cyanotic phlegmons subsequently soften, and draining sinuses result from spontaneous abscess perforation. Both intra-oral and cervical sinuses develop.

*Thoracic actinomycosis* may result from pulmonary, pleural or retropleural infection Usually lobar involvement of a lung, localized empyema and inter-

costal fistula are present. Profound anemia, malaise and pronounced leukocytosis appear before pain and fever are severe.

*Abdominal actinomycosis* is usually apparent as a late or retarded complication of appendicitis, ulcerative ileocecal disease, or abdominal injury. The diagnosis is usually first suggested by fistula formation. In addition to severe anemia and leukocytosis, pain is occasionally severe. Secondary infection is frequent and systemic symptoms, especially emaciation, are common.

In the neglected patient metastatic foci develop in the vertebrae, lungs, liver and kidney with occasional cutaneous abscesses. Extreme chronicity and wasting are features of the infection.

*Treatment.* Election of a program of treatment is influenced by the differential diagnosis of clinical actinomycosis and nocardiosis on the basis of identification of the pathogen. Nocardiosis is a more benign form of the disease and responds well to conservative drainage of abscesses and selective antibiotic therapy. In general, the Wolff-Israel bacillus is sensitive to sulfonamides and penicillin, and the streptothrix organisms of nocardiosis are sensitive to tetracycline compounds and to streptomycin. Sensitivity tests are mandatory for final adoption of the antibacterial therapy.

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The diagnosis depends upon demonstration of the organisms, but some help is afforded by skin and complement fixation tests.

*Treatment.* Treatment is often unsuc-

cessful because diagnosis is apt to be delayed until vital areas have been involved in a destructive granulomatous process. Stilbamidine has been demonstrated to be the drug of choice for treatment.

### RABIES

***Definition.*** The virus of rabies is propagated in dogs and related wild animals and is transmissible to man by the saliva of rabid animals, usually as the result of a bite. After an incubation period varying from 10 days to several months, there develops an almost invariably fatal fulminating encephalitis.

***Pathogenesis.*** Animal rabies complicates the growth of the virus in salivary glands. Encephalitic symptoms in dogs appear 5 days after virus is detectable in the saliva. This is so constant a pattern that failure of rabid signs to develop in the animal within 7 days after a dog bite excludes the possibility of infected saliva at the time of the bite.

Human rabies shows a variable incubation period, owing to variation in the infecting dose. Bites of the exposed surfaces, especially the face and hands, are apt to be more extensive and more heavily inoculated than areas protected by clothing. The shorter incubation period noted in wounds of the face and hand reflects the more massive inoculation with virus.

In both man and animals characteristic and easily demonstrable Negri bodies develop in the cytoplasm of large neurons. Elsewhere in the nervous tissue there are well marked degenerative changes with slight perivascular infiltration with mononuclear cells

***Clinical Course.*** Prodromal symptoms of systemic infection emphasize fever, sore throat, malaise and nausea for 2 to 4 days. The early symptom of greatest significance is altered sensation in and around the area of the bite. Primary sensory nerve stimulation is characteristic in about 80 per cent of cases Symptoms referable to sympathetic nervous system stimulation then follow with pupillary dilatation, sweating, tearing and drooling. Motor excitation predominates usually up to the time of death. This gives rise to the most characteristic sign of the disease, spasm of the muscles of swallowing and breathing when swallowing is attempted. This symptom explains the designation of the disease as hydrophobia. Convulsive seizures are common and death usually occurs during such seizures. Maniacal behavior is rare, but depressive and paralytic symptoms are seen in occasional cases. A more unusual form is that of ascending paralysis of the Landry type. There are no known instances of recovery.

***Differential Diagnosis.*** The history of an animal bite usually serves to exclude other types of encephalitis as likely. However, several problems arise if prophylactic vaccination has been given. Fatal encephalitis without paralysis may result from the use of living vaccine. Paralytic encephalitis may result from sensitization to rabbit brain substances in the vaccine. There is also the possibility of hysterical convulsions after a bite from a supposedly rabid animal.

***Prophylaxis.*** Prevention of human rabies is a complicated problem involving recognition of rabid animals, treatment of the wound and immunization of the victims.

*The Animal Problem.* The major sources of endemic rabies are the domesticated dog and wild animals. Most human cases result from dog bites. Routine vaccination of dogs and adequate control measures for the collection of unlicensed dogs are public health necessities. In the event of an outbreak of rabies, it is wise to enforce a 90-day quarantine of owned dogs with vaccination prior to release, and extermination of all stray dogs. Whenever a dog can be identified as the aggressor in a biting, the animal should be confined under veterinary observation for 7 days If illness develops, the animal may be presumed rabid pending histologic verification of the presence of rabies.

*Treatment of the Wound.* Indirect contact or salivary contamination of the intact and unabraded skin may be ignored. Rabies exposure is assumed possible when there has been salivary con-

tamination of mucous membranes or abraded skin, but the inoculating dose is small under these circumstances. Similarly, the inoculating dose is assumed to be small when the injury is inflicted through clothing and is limited to tooth marks. Severe exposure and large inoculation are possible when the bites are multiple or when exposed surfaces, such as the head, face, neck and hands, are bitten.

Experimental studies have demonstrated that cauterization of the wound with nitric acid prevents rabies when the wound is treated up to 24 hours after inoculation. Recently, it has been shown that a 20 per cent soft soap solution is as effective as nitric acid if applied within 2 hours after the bite. Acid cauterization, therefore, is reserved for those wounds seen more than 2 hours and less than 24 hours after infliction.

*Active Immunization with Vaccine.* Public health authorities are unanimous in their recommendation of vaccination for prevention of rabies after exposure. The clinical evidence is valid that rabies vaccine can offer protection against the disease when the incubation period is greater than one month. The time lag required for active immunity to develop dictates the additional use of hyperimmune serum for severe exposure and the risk of a shorter incubation period.

The Semple vaccine is most generally recommended. The usual treatment consists of 14 daily injections of 2 cc. given at different subcutaneous sites of the abdominal wall. For patients with simple exposure, vaccination is recommended whenever the animal:

1. Is proved to have rabies,
2. Is shown to have microscopic evidence of encephalitis but Negri bodies cannot be demonstrated,
3. Escapes, cannot be identified, or is killed.

The untoward reactions to vaccination are sufficiently frequent to demand careful certification that exposure to rabies has occurred. Review of a large series of vaccinated persons demonstrates that about half had spurious exposure and underwent the risk of lethal vaccine encephalitis unnecessarily. An open wound that has been contaminated with the animal's saliva is justification for treatment. Salivary contamination of unabraded skin or claw scratches do not warrant vaccination.

Patients with nonfatal vaccine encephalitis generally recover without apparent residuals.

The more usual pattern of sensitization neuropathy is that of peripheral neuritis, dorsolumbar myelitis or ascending paralysis. Premonitory signs of a sensitization reaction are erythema and edema at the site of a previous inoculation, usually appearing on the seventh to twelfth day of treatment. Such local reactions are common and subside during continued vaccination. However, if these local reactions are accompanied by lymphadenopathy or such systemic signs as fever, malaise, headache or nausea, the treatment should be stopped at once and administration of cortisone initiated and continued for 10 days. Within this program of management, apprehension about vaccination should not lead to reluctant administration.

*Passive Immunization with Hyperimmune Serum.* It is recognized that severe exposure to a large quantity of the virus may so shorten the incubation period that rabies develops before the vaccine can induce immunity. There is need to combine the use of rabies antiserum with vaccination more generally for bites of the face and head. To be effective the antiserum must be given within 72 hours of injury and preferably within 24 hours. A second dose of antiserum on the fifth day after wounding increases the protection. Whenever severe exposure has occurred, the following rules serve as a guide to treatment:

1. If the animal appears healthy at the time of the biting, only the serum need be given if the animal remains healthy.
2. If the animal appears healthy initially and subsequently appears rabid, serum should be given early and vaccine started at the first signs of rabies in the animal.
3. If the animal is known to be rabid or escapes or is killed at the time of

biting, serum and vaccination should be begun at once.

*Treatment.* There is no known effective treatment for established human rabies

### LEPROSY

Leprosy is primarily a disease of rural peoples in tropical areas. There are an estimated 3,000,000 lepers in the world, with about 750 in the United States. The acid-fast organisms thought to be etiologic cannot be propagated in successive cultures, and they are pathogenic only for man and the rat.

The disease has cutaneous and neural predominance. The cutaneous nodules are usually largest on exposed surfaces of the body, especially the face and hands. Ulceration and secondary infection are common. Sensory peripheral nerves are especially vulnerable and the resultant anesthesia explains trophic ulcerations and mutilating injuries. The disease is one of insidious onset, slow progression and limited contagiousness.

Confirmation of the clinical diagnosis is provided most often by demonstration of acid-fast bacilli in tissue fluid or scrapings from suspected nodules. The Wassermann reaction is frequently positive without other findings of syphilis or yaws. Serologic tests and cutaneous reactions are without value. Sporadic cases may occasionally be confused with peripheral vascular lesions.

Treatment of the proved disease is accomplished most effectively in special leprosariums Sulfones and streptomycin have undoubted therapeutic value and many patients with arrested disease have been returned to gainful and useful living.

### COCCIDIOIDAL GRANULOMA

Coccidioidal granuloma is a secondary complication of primary coccidioidomycosis and is indicative of extensive spread with a likely lethal outcome.

Primary coccidioidomycosis is an airborne disease of the southwestern part of the United States. It appears as a self-limited and relatively benign respiratory infection in those of Caucasian extraction, but may become disseminated in the dark-skinned races especially. In occasional patients erythema nodosum or erythema multiforme develops during the grippe-like initial infection. Alternative names for primary coccidioidomycosis are San Joaquin fever, valley fever and desert rheumatism.

The secondary, or granulomatous, form of the disease appears as foci of metastatic spread in all parts of the body. The histology of the lesions is that of a tubercle without acid-fast organisms. Selective stains identify the thick-walled spherules, but positive identification of the spore as Coccidioides may require collateral support. Complement-fixing antibodies appear in the serum of some patients and are thought to indicate spreading infection and poor prognosis.

Amphotericin B, given during a period of several months, has effected cure in several long-standing infections. Occasionally, a primary infection of the lung may progress to a solitary granuloma curable by local resection. Elsewhere, especially on the skin, granulomas are usually indicative of widespread metastases, but occasionally solitary granulomas may occur as the result of secondary infection of cutaneous abrasions. The diagnosis is established by study of the excised specimen.

### TUBERCULOSIS

Tuberculous infection may be exudative or granulomatous (proliferative). Animal experiments suggest that immunity accelerates tubercle formation and that hypersensitivity is associated with caseation necrosis. Both exudative and granulomatous lesions may progress to caseation necrosis. Such incongruities emphasize the impracticability of attempting to classify tuberculous lesions as "spreading" or "localized," as is commonly done with pyogenic infections. Preferable differentiation is as "active" or "inactive," the latter term being reserved for focal lesions exteriorized within the body by a circumferential scar. These inactive lesions are frequently available for surgical excision as a preventive against subsequent exacerbation.

Present chemotherapy has facilitated conversion of active to quiescent foci and expanded the surgical opportunity for control of tuberculosis.

Surgical excision of inactive tuberculous foci is always undertaken as a staged procedure in a premeditated plan of total management. The drugs of choice for retardation of the growth of tubercle bacilli are streptomycin and isoniazid. These are supplemental to the usual dietary and hygienic regimen.

Systemic and visceral types of tuberculosis are beyond the scope of this discussion, and attention here is directed to cold abscesses, external sinuses and fistulas, and lymph node infection.

Cold abscesses appear as areas of fluctuation without the usual signs of heat, erythema and tenderness. They most usually represent fascial plane dissection of caseous pus arising in relation to a bony focus of tuberculosis. The characteristic pus may be obtained by needle aspiration, but it is wise to introduce the needle through peripheral sound tissue to prevent early sinus formation. Usually, no organisms can be found on smear, but culture or animal inoculation reveals the acid-fast bacilli. The commonest sites of cold abscesses are the parasternal area and the groin. Parasternal abscesses are usually dumb-bell in configuration as the result of intrathoracic and extrathoracic extension from costochondral infections. Groin abscesses represent the subcutaneous extension of pus arising from vertebral disease and dissecting along the fascial plane of the "psoas abscess." Neglected cases of cold abscess perforate spontaneously and draining sinuses and fistulas result. These are notoriously refractory to simple excision and closure, but many will heal spontaneously on appropriate treatment and antibiotic therapy.

Granulomatous infection of the breast and epididymis may progress to caseation necrosis and fistula formation. Tuberculous mastitis is an especially difficult lesion to treat because of the massive scarring; mastectomy is occasionally required.

Tuberculous lymphadenitis is especially prone to develop in the cervical lymph nodes, where it used to be known as "scrofula" or "king's evil." The lymph nodes are enlarged and characteristically matted together. Healing, calcification and caseation necrosis progress concomitantly in different nodes. Sinus formation is fairly frequent in neglected cases. The tuberculous etiology is most often established on biopsy diagnosis, but radical neck dissection is contraindicated because of the technical impossibility of satisfactory cure by this approach alone.

Once the diagnosis is established, proper supportive care, controlled chemotherapy and total evaluation of the patient and the extent of the disease are necessary. Minor surgical procedures are useful only in the management of tuberculous lymphadenitis without evidence of visceral or systemic disease. Scrofulous fistulas or sinuses persisting after the second week of treatment almost invariably lead to calcific or necrotic lymph nodes amenable to surgical removal with simple local excision. This has been found to be practical and expeditious. When sinuses lead to osseous foci, more complicated surgical maneuvers are usually indicated.

### TETANUS

Tetanus, or "lockjaw," was known to the ancients as a scourge of parturient women, newborn babies and wounded soldiers. The disease results from the pharmacologic effect of an extremely potent exotoxin having an especial affinity for cells of the central nervous system. The etiologic agent, *Clostridium tetani,* is a spore-forming anaerobe occurring in the feces of man and animals and capable of long survival in the soil. The clinical syndrome is characterized by sustained spasm of voluntary muscles, lowered threshold of muscular irritability, intermittent convulsive seizures and ultimate failure of medullary centers. The toxemia attributable to infection with this organism is quite properly held to be preventable within modern concepts of wound management and immunization.

***Etiologic Agent.*** *Clostridium tetani* is an obligate anaerobe with gram-positive

vegetative and spore forms. The vegetative form is bacillary, motile and nonencapsulated. The spore is located terminally with a characteristic baton, or "drum-stick," appearance. Several antigenically distinct bacterial types produce an identical exotoxin. Morphologically similar bacteria failing to produce toxin are classified as *Cl. tetanomorphum*. All these organisms are extremely sensitive to penicillin. The vegetative forms and the exotoxin are destroyed by heating to 65° C. for 10 minutes. Autoclaving for 20 minutes at 115° C. is necessary to destroy the spores.

The important neurotoxin is tetanospasmin. An exotoxic lecithinase, tetanolysin, causes lysis of red blood cells in vitro but is not generally considered of clinical importance. Pathogenicity in the case of *Cl. tetani* is determined solely by toxigenicity, for the bacilli are not at all invasive. The estimated minimal lethal dose of the toxin for man is 0.13 mg.

*Pathogenesis.* The mechanism whereby *Cl. tetani* gains access to the body is one of wound contamination by soil, dust or feces. The growth of toxin-producing vegetative forms is initially dependent upon an anaerobic environment in a wound Both blood clot and devitalized tissue supply this environment and growth essentials, but other factors may also be important. Calcium chloride, occasionally present in soil, further lowers the redox potential of injured muscle. Atelectasis of the lung from aspiration of garden soil has been followed by tetanus. Once toxin production has been initiated, however, the toxin contributes to maintenance of optimal growth conditions. It seems likely that tetanolysin, with known gelatinase, esterase, lipase and lecithinase effects, is of more importance here than tetanospasmin.

The blood-borne neurotoxin is specifically absorbed by the cells of the brain and spinal cord and, once absorbed by these cells, is no longer susceptible to neutralization by specific antitoxin. Hence, every effort must be made to provide antitoxin to neutralize the toxin as it is released from the primary focus and before it is absorbed by the cells of the central nervous system.

It is generally agreed that blood-borne toxin results in generalized tetanus. Occasionally, localized tetanus with spasm of the muscle groups in relation to the wound of entry may precede development of generalized tetanus. The incubation period demonstrable in experiments on localized tetanus and the prevention of localized tetanus by prior neurectomy suggest that the phenomenon of local tetanus is of central origin and depends upon nerve transport of the toxin. The evidence opposes the concept of a purely peripheral action of the toxin upon neuromuscular end organs.

There is no demonstrable damage to sensitive nerve cells exposed to tetanus toxin. The effect is pharmacologic disruption of neurophysiologic mechanisms concerned with transmission of motor nerve impulses. Upon recovery from tetanus, there are no demonstrable residuals of the impaired function.

*Clinical Course.* The incubation period of tetanus varies from 2 days to several months, the usual period being 6 to 15 days. The prognosis is graver for incubation periods of less than 10 days.

Multiple aches and pains, irritability and headache are important prodromal complaints. The early symptoms of generalized tetanus, in order of importance, are stiffness of the neck with or without pain in the back, trismus, stiffness of the extremity, and opisthotonos. Later findings are risus sardonicus, dysphagia, spasm of the abdominal muscles, "cogwheel" resistance to passive movement of the extremities and generalized spastic seizures. Fever is minimal and the sensorium is clear.

Improvement in the supportive care of afflicted patients has reduced the expected mortality rate to about 25 per cent. Patients destined to recover gradually improve during the second week of symptoms. Although complete recovery may be postponed for several weeks, there are no neurologic residuals attributable to the toxemia, nor is there any immunity in consequence of recovery.

*Prophylaxis of Tetanus.* Rigid asepsis in elective surgery is sometimes violated by the use of plastic materials unable to withstand the autoclaving temperatures

necessary to destroy the tetanus spores. It is most unwise to take chances with an organism as ubiquitous as the *Cl. tetani*. It is important that *every contaminated wound* be considered as harboring tetanal bacteria. Not only should all such wounds have thorough and prompt débridement, but delayed closure should be utilized for many civilian injuries and all military wounds. Great success has attended the prevention of tetanus by maintaining a serum concentration of 0.1 unit of tetanus antitoxin per milliliter of blood in the injured person. This may be done by passive or active immunization, but the emphasis today is upon routine active immunization. The great hope for a reduced clinical incidence of tetanus lies in universal active immunization, for the greatest incidence of tetanus now occurs with wounds so insignificant that professional attention was never sought. Further, the incidence of serum reactions is sufficiently high to render routine passive immunization with repeated injuries impractical.

*Passive Immunization.* Passive immunization is mandatory for patients not previously immunized with toxoid. The use of concentrated horse serum containing tetanus antitoxin should always be preceded by appropriate tests for sensitivity. It is wrong to perform the sensitivity tests with the neat serum. Accurate skin or ophthalmic testing demands dilution of the neat serum 1:100 in saline solution. If the reaction to the skin test is negative, the dosage of antitoxin selected is determined by the time of anticipated hazard from the wound: the usual 1500 units provides a protective level for 1 to 3 weeks, 10,000 units for 4 to 6 weeks, and 100,000 units for 6 to 10 weeks. It is also wise to increase the prophylactic dosage above 1500 units of antitoxin when the wound is seen 24 hours or more after its occurrence. Antitoxin appears in the spinal fluid in consequence of passive immunization. The antitoxin is absorbed equally well after intracutaneous or intramuscular injection.

In the event of positive reactions indicating sensitivity to horse serum, recourse to bovine antitoxin is the procedure of choice. Lack of demand for bovine antitoxin and present emphasis on toxoid immunization have led to the practical disappearance of bovine antitoxin from the shelves of pharmacists. Management of the patient sensitive to horse serum without available bovine antitoxin presents an enigma. Attempts at desensitization are not warranted, for the risk of serious allergenic reaction is great and successful passive immunization is extremely unlikely. If tetanus prophylaxis is mandatory for a patient sensitive to the serum, adequate passive immunization may be achieved by whole blood or plasma transfusions from donors with high serum antitoxin levels from active immunization (2 weeks to 3 months after a "booster" dose of toxoid).

In approximately 20 per cent of patients some allergenic reaction to the first dose of tetanus antitoxin may be expected to develop. Since some of these have serious neurologic residuals, it may be wise routinely to give 0.3 ml. of Adrenalin in an oily base immediately and to prescribe antihistamine drugs for 10 days after prophylactic use of tetanus antitoxin.

*Active Immunization.* Active immunization with tetanus toxoid, as now available, produces no allergic reactions, confers durable immunity and is more effective than passive immunization with antitoxin. It is desirable that the entire population, both military and civilian, be immunized and that this immunity be maintained by "booster" doses at appropriate intervals. The antigenicity of the toxoid is apparently enhanced by combination with typhoid vaccine or diphtheria toxoid.

Tetanus toxoid is available as alum toxoid (precipitated) or as fluid toxoid. In general, the alum toxoid is preferred for basic vaccination and the fluid toxoid is preferred for "booster" doses. The circulating level of antitoxin necessary for clinical protection is 0.01 to 0.02 units of antitoxin per millimeter of serum.

A satisfactory program of basic vaccination consists of 3 injections of 0.5 ml. of toxoid. The second injection is given 6 *weeks* after the first, and the third injection is given 6 to 12 *months* later. The third injection completes the basic immunization and is not a "booster" dose.

The resulting *antitoxic titers* remain at what is assumed to be a protective level for 2 years and decrease gradually thereafter. Rare exceptions to this general rule are classified as "poor reactors."

The "booster" dose is 0.5 ml. of toxoid. The following observations are useful guides in prophylaxis:

1. For 4 years after the last dose of the basic vaccination, a "booster" dose produces an anamnestic recall of circulating antitoxin that is maximal on the fourth or fifth day.

2. After the lapse of 4 years from the basic vaccination, the time required for maximal response may be prolonged to 14 days, but an adequately protective antitoxic titer may precede the maximal titer by several days.

3. For sustained protection against tetanus from trivial injury among especially vulnerable groups, such as farmers, the "booster" dose should be given every 2 years.

4. To preserve a prompt response to "booster" doses given at times of injury, the "booster" injection should be given every 4 years.

*Combined Active and Passive Immunization for Patients Previously Vaccinated with Toxoid.* The problem occasionally arises as to the wisdom of giving both toxoid and antitoxin to a person previously vaccinated with toxoid. Review of the few patients in whom tetanus developed after a "booster" dose given after wounding reveals a high incidence of delayed treatment and of fulminating tetanus with a short incubation period.

The situations wherein previously immunized persons should receive both toxoid and antitoxin have been defined as follows:

1. The "poor reactor," frequently unidentified, who has failed to respond in the usual way to prior basic vaccination.

2. The massively contaminated wound with delayed initial surgical treatment wherein rapidly fatal tetanus or a short incubation period is an especial hazard.

3. The lapse of more than 4 years from the time of the fourth dose in the basic vaccination or the last "booster" dose, a situation wherein a small but definite group of previously immunized patients are known to require 6 or more days for antitoxin response to a "booster" dose of fluid toxoid.

Acknowledgment of these special indications for both toxoid and antitoxin should in no way invalidate usual reliance upon toxoid alone. "Booster" doses at the time of wounding are adequate prophylaxis when basic 3-dose vaccination has been supplemented with "booster" doses every 4 years thereafter. Continuous, or sustained, immunity demands "booster" doses every 2 years.

Certain precautions must be observed when antitoxin and toxoid are given at the same time. The injections should be made in separate syringes and at separate sites, for it has been shown that prior mixing of toxoid and antitoxin impairs the antigenicity of the toxoid. Further, the dose of toxoid should contain at least 10 Lf., or 1 ml., because small doses are less antigenic in the presence of antitoxic antibodies. The recommended dose of toxoid, however, can bind no more than 40 units of antitoxin.

*Combined Active and Passive Immunization for Patients NOT Previously Vaccinated with Toxoid.* The high incidence of sensitization to horse protein in consequence of a prophylactic dose of antitoxin is well known. Therefore, once antitoxin has been used, either for prophylaxis or for treatment, there is a real obligation to employ toxoid immunization in anticipation of further injuries demanding protection from tetanus. It is also true that trivial injuries escaping medical observation are a major source of tetanus. True prevention of tetanus demands active immunization for all.

Although present pediatric routine immunization has broadened the actively immune group, patients still present themselves with injuries and no history

of toxoid vaccination. In addition to antitoxin, these patients should also receive toxoid at the same time. The toxoid given constitutes the first dose of the basic vaccination program but contributes nothing to the protection of the patient as an initial dose. The patient must return at monthly intervals to complete the immunization.

*Prognosis.* Tetanus is an extremely grave disease with a mortality rate of approximately 25 per cent. Recovery occurs without residual attributable to the toxemia, and the disease does not confer immunity. Active immunization with toxoid provides the most effective prophylaxis known to medical science.

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*Chapter 12*

# Diseases of the Breast

*By Alton Ochsner*

Diseases of the breast are extremely important, primarily because of the possibility that these lesions might be cancerous. Until recently, the most frequent site of human cancer was the breast, and only in the past five years has the lung superseded the breast in this regard. Many women consult physicians because of symptoms referable to the breast. Whereas a quarter of a century ago most women consulting physicians for this reason had malignant tumors, at present it is gratifying that most women complaining of symptoms referable to the breast have benign lesions This is indeed a tribute to the success of the educational program of the American Cancer Society, which has made women cognizant of the frequency of malignant disease of the breast. It has been largely responsible for making women with diseases of the breast consult their physicians early in order to determine the cause.

Self-examination of the breast by women, as advocated by the American Cancer Society, has greatly facilitated early detection of lesions. Usually a female patient consults a physician because of either pain or a lump within the breast. Malignant neoplasms of the breast usually cause pain only in the late stages when the lesion is quite extensive. Therefore, if the complaint is primarily pain, the lesion is likely to be benign.

## EXAMINATION OF THE BREAST

Careful examination of the breasts is extremely important. Much can be learned by observation of the contour of the breast and establishment of the presence or absence of fixation of the breast either to the overlying skin or to the thoracic wall. This examination is best done with the patient sitting and facing the examiner. Fixation of the mammary tissue to the deep fascia or skin can usually be detected by observing the movement of the breasts when the patient raises her arms and when the pectoral muscles are contracted by having her place her hands against her hips and press inward. Palpation of the breast is done best against the thoracic wall with the patient supine. All quadrants of the breast should be carefully and systematically examined to determine differences in consistency and the presence or absence of masses. The axillas and supraclavicular fossas should be carefully palpated. If there is any discharge from the breast, smears should be made for microscopic examination.

## CHRONIC CYSTIC MASTITIS

The most frequent lesion in the female breast is a condition which has been described by many terms: chronic cystic mastitis, cystic disease, Schimmelbusch's disease, mazoplasia, adenosis and blue dome cysts. It may occur in women of all ages, the greatest frequency being between the ages of 35 and 40 years. The disease usually disappears at the time of the menopause. It probably results from an endocrine imbalance, most likely progesterone deficiency. It causes considerable discomfort and at times pain, which is usually worse before or during menstruation and is likely to be aggravated by activity.

On examination, diffuse bilateral nodularity and tenderness of the breasts are

detected. Occasionally, distinct masses, most of which are globular and fluctuant, are felt. Transillumination of the breast, which must be performed in complete darkness, is a valuable method of examination. Most cysts, unless filled with blood or turbid material, transilluminate well; this is of diagnostic importance in differentiating them from solid masses (Fig. 131).

Cystic disease is a benign lesion that is of significance because it produces symptoms, particularly pain, and because it might be confused with a malignant lesion. There is some difference of opinion concerning whether cancer of the breast develops more frequently in women with chronic cystic mastitis than in those without this abnormality. Warren[1] estimated the incidence of mammary cancer developing in women with chronic cystic mastitis to be about four and one half times as great as in other women. In women between 30 and 49 years of age it was 11.7 times higher, whereas in those older than 50 years of age it was two and one half times higher. This observation emphasizes the importance of periodic examinations of all patients with cystic mastitis in order to detect a neoplastic lesion if one should develop. Many authorities, however, such as Adair,[2] believe that the incidence of cancer developing in the breasts of women with chronic cystic mastitis is no higher than that in the general female population, which, according to Campbell,[3] is 2 per cent. In more than 400 of Adair's cases, mammary cancer subsequently developed in only 3, and he considered this to be coincidental.

Treatment of a mass in the breast diagnosed with reasonable certainty as cystic because it is globular, fluctuant and translucent consists in simple aspiration with use of local analgesia as an office procedure. A 1 per cent solution of procaine is injected in the skin overlying the cyst. While the cyst is held immobile between the thumb and index finger of the left hand, an aspirating needle attached to a syringe is introduced into the lumen of the cyst, the contents are aspirated and the cyst is entirely evacuated (Fig. 132). The aspirated fluid should be examined microscopically because much can be determined from cytologic examination. After the cyst has been evacuated, the breast is carefully examined to determine whether the mass has completely disappeared. If it has not completely disappeared or if cytologic examination suggests neoplastic change, it would be unwise to continue conservative therapy. At least resection of that quadrant of the breast should be advised. Also, if the cyst reaccumulates within two or three weeks, resection of the quadrant containing the cyst is indicated.

Aside from aspirating large cysts, treatment of chronic cystic disease consists largely in reassurance and use of proper support for the breast. Because chronic cystic mastitis is probably due to progesterone deficiency, administration of this ovarian hormone frequently results in relief of pain and prevention of re-

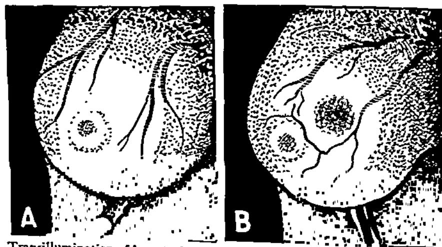



*Figure 131.* Transillumination of breast. *A*, Cyst transilluminates well *B*, Solid tumor casts a shadow.

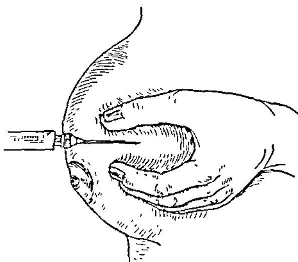


*Figure 132.* Technique of aspirating cyst of breast. With use of a local analgesia, the cyst is held between the thumb and finger of the left hand. A wheal is raised on the skin overlying the cyst, and a needle attached to a syringe is introduced into the cyst, the contents being aspirated.

currence of cysts. Unfortunately, up to the present time the only efficacious method of administering progesterone to these patients has been daily intramuscular injection during the last half of the menstrual cycle, however, potent progesterone hormones for oral administration *will* probably soon be available.[4]

## NIPPLE DISCHARGE

Discharge from the nipple, aside from that from the nonlactating breast, occurs less frequently than cystic mastitis. It may be *associated with cystic mastitis* as well as other conditions. Of 72 cases observed by Abramson and Tucker,[5] 23 (31.9 per cent) were associated with chronic cystic mastitis, 25 (35.7 per cent) with carcinoma, 14 (19.9 per cent) with intraductal papilloma, 5 (6.9 per cent) with fibroadenoma, 4 (5.5 per cent) with abscess of the breast, and 1 (1.3 per cent) with lipoma of the breast. Thus, about one-third of the patients with discharge

of whom 18 (45 per cent) had carcinoma and 8 (20 per cent) intraductal papilloma. Bloody discharge from the nipple, therefore, may be a sign of serious disease and should never be disregarded. Kilgore and associates,[6] however, found that bleeding from the nipple was associated with benign papillary disease three times more frequently than with cancer.

*Discharge from the nipple should be* carefully examined microscopically because, as has been shown by Jackson and Severance,[7] the cause of the discharge can usually be determined by careful cytologic examination. In 581 of the women they examined, mammary *secretion was obtained 974 times. Neo*plastic cells were found in 131 samples and no neoplastic cells in 843; 51 of the former patients were operated upon; *in* 38 (74.5 per cent) either papilloma or carcinoma was found and *in* 13 (25.5 per cent) neither of these lesions was found. *Discharge from the nipple is common* and in most instances of no significance, particularly if it is not bloody. However, persistent hemorrhagic discharge from the nipple demands further investigation and resection of the quadrant from which the bleeding persists or simple mastectomy should be advised.

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*Part III*

# Musculoskeletal System

*Chapter 13*

# Deformities and Anomalies

By Guy A. Caldwell and Harry D. Morris

## TORTICOLLIS OR WRYNECK

Torticollis is a cervical deformity usually produced by shortening of the sternocleidomastoid muscle on one side, causing the head to tilt towards the shoulder on the affected side and the chin to rotate towards the opposite shoulder. It may occur in patients of any age and may be congenital or acquired.

In the congenital form the deformity is apparent at birth. In some it is due to a primary congenital defect of the cervical vertebrae but in most it is caused by secondary congenital changes, such as abnormal position of the head in utero or injury to the sternocleidomastoid muscle during birth.

Acquired torticollis includes several types. The *acute* type results from injured muscles or ligaments, myositis (an inflammatory reaction of the muscles) or lymphadenitis. *Spasmodic* torticollis results from an organic disorder of the central nervous system which produces intermittent or spasmodic contractions of the sternocleidomastoid and associated muscles. *Hysterical* torticollis is due to psychogenic inability of the patient to control the cervical muscles.

Torticollis may also be *associated* with such primary conditions as tuberculosis or osteomyelitis of the cervical vertebrae, arthritis, paralyses involving the muscles on one side of the neck, soft tissue contractures after burns or other severe injuries, and scoliosis.

Of these various types of torticollis, some of the *congenital* and most *acute* cases are amenable to treatment in the office.

*Congenital Torticollis (Fig. 133).* Absence of pain is characteristic of all types of congenital torticollis. If the deformity is caused by bony defects and malformations of the cervical spine, special orthopedic and operative measures are required and ultimate complete correction is problematic, whereas if the lesion is in the sternocleidomastoid muscle and the condition is recognized in the early weeks of life, consistent stretching followed by massage of the muscle often completely corrects the condition. Torticollis may be recognized in the early postnatal days by the infant's tendency to keep the head tilted towards one shoulder and by the presence of a nontender, cylindrical enlargement in the midportion of the sternocleidomastoid muscle. This occurs more often in female babies and on the left side. After a few weeks the attention of the parents may be directed to the asymmetry of the head and face caused by the infant's tendency to lie only on one side with the head tilted.

The tumefaction in the muscle is presumed by some to consist of a hematoma that has been produced by a rupture of many of the muscle fibers during birth. Consistent gentle stretching of the muscles several times daily, accompanied by massage over the muscle, may cause diminution in size over a period of three to six months with eventual disappearance, leaving a full-length, normally functioning muscle. However, if it does not regress completely and fibrous replacement occurs with subsequent shrinkage, shortening and deformity, then conservative measures must be abandoned and correction obtained by tenotomies of sternal and clavicular origins of the muscle followed by mainte-

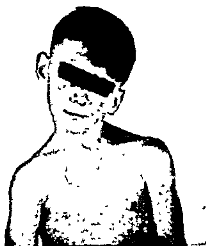


*Figure 133.* Congenital torticollis (wryneck)

nance of the overcorrected position of the head and neck in a brace or plaster.

Sometimes the deformity is so slight that it is overlooked until the baby begins walking or even later. By that time flattening and shortening of the face and elevation of the shoulder on the affected side are usually present. The cervical spine may be curved and the ocular balance so disturbed as to produce eyestrain. Flexion and extension of the neck are free, but turning movements and lateral bending are restricted. However, there is no pain associated with any stage of the deformity.

In these older children operative release of the contracted muscle is imperative and must be followed by use of a brace or plaster cast to maintain the overcorrected position for six months or longer, after which stretching exercises should be continued for many months until the child can move the head as far in one direction as another. If the deformity is corrected before the third or fourth year and good postoperative care is provided, the facial asymmetry usually disappears entirely and considerable improvement occurs even when the correction is accomplished at a later age.

*Acute torticollis* (acquired) is usually *accompanied by pain* and is seen in patients of all ages. Whether the condition is the result of a sudden jerk or wrenching of the neck that sprains one or more of the articulations, or is a myositis that develops spontaneously in the muscles on one side, the effect is much the same and the treatment is similar.

*Symptoms.* The patient holds the neck rigidly and is afraid to move it in any direction because certain movements produce sharp twinges of pain in various parts of the neck. When asked to look far to one side, the patient will turn the whole body rather than try to turn the head. On lying down or getting up he is likely to grasp his head with his hands to avoid placing strain on the cervical muscles. He finds it difficult to adjust his pillow and to assume a comfortable position in bed. However, the head is seldom tilted far to one side or the chin rotated well towards the opposite shoulder, as is sometimes seen in the hysterical type. The symptoms develop rapidly and become severe a few hours after injury or may develop overnight in the case of acute myositis.

On examination, with the patient in the sitting position, the neck is usually held fixed and all muscles on both sides may be tense, but the sternocleidomastoid and scaleni on the affected side are quite rigid and tender. When the patient is lying down relaxed, the head can be gently rotated or tilted passively through a moderate range of motion, especially if gentle traction is made on the head at the same time. However, movements that stretch the tender, affected muscles or ligaments will always produce a sharp twinge of pain. Roentgenograms of the cervical spine may reveal no evidence of fracture, dislocation or disease, but in patients over 40 years of age they often reveal hypertrophic changes and narrowing of one or more cervical intervertebral disks.

When there is a history of injury, it is important to rule out subluxations, dislocations and fracture dislocations of the cervical spine. It must be recognized that dormant cervical arthritis may be activated by injury. A destructive lesion of one of the cervical vertebrae, such as tuberculosis or a tumor, may not produce noticeable symptoms until aggravated by some slight cervical injury.

*Treatment.* The method of treatment of acute wryneck will vary with the severity and duration of the symptoms. Severe traumatic torticollis responds more quickly if the patient is placed in

bed with traction of 3 to 5 pounds of weight attached to a head halter. This should be supplemented with sedatives, opiates at first and aspirin later. After two or three days, when the patient can turn his head and local tenderness has diminished, he may become ambulatory if he wears a modified Thomas collar and is given daily treatments with diathermy and massage in the physical therapy department, or he may use a hot pad followed by massage at home. Usually 5 to 10 grains of aspirin four times a day should be given until the pain has disappeared. In milder cases the preliminary bed treatment may not be necessary.

In acute myositis, rest in bed with application of a hot pad to the back and side of the neck, combined with administration of mild sedatives, usually gives relief in a day or two. Recently, certain muscle relaxants such as Tolserol (myanesin), 1 gm. every 4 hours, or neostigmine with atropine, 1/50 grain, have been used with benefit. Head traction is usually unnecessary and sometimes seems to aggravate the symptoms. The use of a Thomas collar is usually not required, but daily treatments of heat and massage should be continued for seven to ten days until the symptoms disappear. Such patients should be advised to avoid a draft of cold air against the side of the neck and it often is helpful to keep the neck and shoulders well covered at night to prevent recurrence.

### CERVICAL RIB

Congenital elongation of one or both transverse processes of the seventh cervical vertebra, if slight, is not clinically significant. However, in rare cases, as the child grows, the rib elongates and may reach the posterior border of the scalenus posticus or scalenus anticus, or it may even project beyond this. Therefore, it may present itself in the supraclavicular fossa as a palpable bony tumor. It seldom is apparent on inspection but may be noted on palpation even in young children and may be visualized in roentgenograms of the cervicodorsal spine. In most instances there are no associated symptoms and cervical ribs are discovered incidentally. The associated symptoms of ulnar paresthesia and diminished blood supply to the arm and hand seldom appear before puberty or adult life. When present, the symptoms are similar to those of the scalenus anticus syndrome described by Ochsner, Gage and DeBakey in 1935. Adson and Coffey showed that in cases of cervical rib, simple section of the muscle will, with rare exception, produce relief of symptoms. Section of the scalenus muscle is a simpler procedure than resection of the rib and is now considered the method of choice. This, however, is a major surgical procedure requiring hospitalization.

### CLEIDOCRANIAL DYSOSTOSIS

Cleidocranial dysostosis denotes partial or complete absence of both clavicles associated with delayed ossification of the fontanelles and increased transverse diameter of the skull. The deformity is hereditary in approximately half of the cases and occurs about as often in males as in females. As a rule there is little or no disability and treatment is seldom indicated.

### SPRENGEL'S DEFORMITY
(Congenital Elevation of the Scapula)

In this congenital deformity the scapula on one side is elevated 2 to 10 cm. above the level of the opposite normal scapula and the inferior angle is rotated medially. It is often associated with torticollis and curvature of the spine. Partial correction may be obtained in childhood by operative measures followed by suitable exercises.

### CONGENITAL SYNOSTOSIS OF THE CERVICAL SPINE
(Klippel-Feil Syndrome)

Congenital synostosis of the cervical spine is a rare malformation in which the lower cervical vertebrae are fused into one homogeneous mass. Usually this anomaly is associated with spina bifida of the lower cervical and upper dorsal vertebrae. Congenital anomalies in other parts of the body are often present. The

child has a short, thick neck, the movements of which are limited in all directions. Treatment is usually not helpful.

### CONGENITAL SCOLIOSIS

Curvature of the spine in an infant is usually dependent upon the presence of one or more hemivertebrae. The lateral half of one or more vertebrae fails to develop, thus producing a sharp curve in the spine that tends to increase with growth. When such hemivertebrae occur in the dorsal spine, there is corresponding absence of ribs on the side of the vertebral defect.

In most instances this is a progressive deformity that is not only disfiguring but also disabling when neglected. The condition can be considerably improved by suitable orthopedic measures and operations properly timed during the early growing years.

### CONGENITAL PELVIC DEFORMITIES

Asymmetric development of the two innominate bones is often associated with asymmetric development of the legs and shortening on the affected side. Treatment is directed towards equalizing the length of the legs by use of shoe lifts. If the shortening increases with growth, retardation of growth on the normal side by epiphyseal arrest should be considered.

### SPINA BIFIDA OCCULTA

Failure of fusion of the lamina of one or more vertebrae to form a spinous process results in a neural arch defect of varying degree. Large defects associated with meningocele are neurosurgical problems. Small defects of the lamina alone are not in themselves clinically significant but they are often associated with other anomalies, especially in the lower portion of the back, with resultant symptoms of instability of the spine.

### SPONDYLOLYSIS, SPONDYLOLISTHESIS, OTHER LUMBOSACRAL ANOMALIES

A bilateral defect of the pedicle or isthmus without anteroposterior displacement is designated *spondylolysis.* When the isthmic defects are associated with displacement of varying degrees, the condition is called *spondylolisthesis.* Both are often present without producing symptoms, but spondylolisthesis represents poor stability of the spine and eventually will cause some low back pain, whereas spondylolysis may persist without noticeable symptoms even in those engaged in strenuous work or athletic activities.

Other congenital anomalies frequently seen in the lumbosacral region of the spine relate to the articular (zygapophyseal) process. These include fissure defects or fractures of inferior articular processes, tropism or asymmetric development of the zygapophyses, or sacralization of one of the transverse processes of the fifth lumbar vertebra. Any one or a combination of these may be present without producing symptoms, although they represent faults in the mechanics of the spine. However, in the presence of disabling symptoms clearly referable to these joints it is possible that these anomalies have been a predisposing cause.

Discussion of symptoms and treatment of such disorders will be given under the heading *The Lumbar Spine* in Chapter 14.

### CONGENITAL DEFORMITIES OF UPPER EXTREMITY

Congenital deformities of the upper extremity are not common, but the variety is great, ranging from an extra finger to complete absence of the whole extremity. Frequently these are associated with other congenital defects of the trunk or legs. For the most part they are all too obvious and disabling. For a few of these much can be done by orthopedic, plastic and surgical measures properly timed in relation to growth of the child but, unfortunately, little or nothing can be done to improve many cases. Treatment for those that can be helped is for the most part highly specialized and none of it falls in the realm of minor surgery. Corrective surgical procedures range from simple amputation and plastic skin procedures to com-

plicated bone resections or bone transplants combined with plastic surgery. These patients should be referred to competent specialists for observation early in life, although many of the corrective orthopedic procedures will be deferred in order not to retard bone growth.

A partial list of these deformities with their definitions will be given without discussion of the treatment.

*Polydactylism (Supernumerary Digits).* There are four varieties of the deformity: (1) a rudimentary digit loosely attached to any part of the hand or foot (Fig. 134) or to another digit (Fig. 135); (2) a more or less developed digit, articulating with the head or side of a metacarpal or phalangeal bone; (3) a perfect digit with metacarpal bone of its own; (4) a digit united in its length to another articulating with a metacarpal bone of its own or with one shared by another digit.

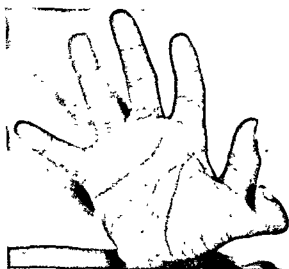


*Figure 134.* Polydactylism (supernumerary digits). (Courtesy of Pullen, R: Applied Physical Diagnosis. Philadelphia, W. B. Saunders Co., 1944)



*Figure 135.* Lower extremity, polydactylism (supernumerary digits).

*Syndactylism (Webbed Fingers).* Congenital webbing of the fingers may involve the spaces between any of the fingers and may be of varying length extending even to the finger tips in some cases. Four groups may be identified: (1) the union may consist of only a thin membrane; (2) the web may consist of skin of normal thickness; (3) the connection may be a firm one consisting of skin and fascia, fusing the two fingers into one, with perhaps only a single nail for the two; and (4) the union may be osseous, generally affecting the terminal phalanges but also at times causing fusion of all of the bones of the two fingers.

*Flexion or Hyperextension Contractures.* Flexion contractures usually occur in the fifth finger, whereas hyperextension contractures may affect the terminal, middle or proximal phalanges of any of the fingers.

*Macrodactylia* consists of hyperplastic, giant overgrowth of one or several digits. It is usually not associated with other deformities, is seldom bilateral and usually not hereditary.

*Cleft Hands.* Congenitally split hands include the lobster-claw hand, with only a thumb and little finger, and mirror hands, with two or three digits on either side of the cleft.

*Club Hands.* These may be due to contracture of soft parts producing fixed radial or ulnar deviation, or to congenital shortening or absence of the radius or ulna.

*Absence of Segments.* There may be total absence of fingers, metacarpals, wrist bones, the forearm or even the entire arm. The humerus may be absent with a rudimentary forearm and hand present.

*Congenital Dislocation of Radial Head.* The head of the radius may be dislocated in an arm that is otherwise normal, but this more often occurs with congenital shortening of the ulna.

*Synostosis of Upper End of Radius and Ulna.* A bony bridge is found uniting the upper part of the shafts of

radius and ulna which prevents supination and pronation.

*Congenital Ankylosis of Elbow.* The elbow joint may be completely fused at varying angles.

### CONGENITAL DEFORMITIES OF THE LOWER EXTREMITIES

Many of the congenital deformities of the lower extremities follow the same pattern as those of the upper extremity. Polydactylism, syndactylism, cleft foot, clubfoot, congenital absence of part or all of the tibia, fibula or femur, dislocation of the knee (recurvatum) and dislocation of one or both hips may exist. However, there are many other deformities in addition, such as hemihypertrophy of a leg or foot, unilateral hypertrophy of one or more toes, anterior bowing of the tibia, congenital amputations, and congenital constrictions.

*Achondroplasia* is a condition of abnormal osteogenesis that begins during intrauterine life and produces a dwarf. Chondrodystrophia fetalis is characterized by an altered rate of growth of bone from cartilage, resulting in irregularity of the epiphyseal lines and broad, flat bones with hip and knee deformities. Osteogenesis imperfecta congenita is a condition in which multiple fractures occur at birth or in early life and osteogenesis imperfecta tarda (fragilitas osseum) one in which fractures occur from the eighth to the sixteenth year. This is also referred to as hereditary osteopsathyrosis (brittle bones and blue sclera).

*Multiple cartilaginous exostoses* appear in the growing ends of long bones near the joints, are found most often between the ages of nine and twenty years and can usually be traced through several generations.

*Congenital dislocation of the hip* is seen more frequently in girls than in boys and the central European races seem to be predisposed to this deformity. Diagnosis in the infant is aided by certain physical signs:

1. The skin creases on the inner sides of the two thighs are at different levels.
2. If both hips are flexed to 90 degrees and then abducted as far as possible, the dislocated hip does not abduct as fully as the normal one. Normally, an infant's hips can be placed in the "frog position" without difficulty.
3. On grasping the baby's knee with one hand and alternately pushing and pulling on the femur and at the same time keeping the other hand on the pelvis and trochanter on the same side, the examiner can feel the slipping and instability of the femoral head in relation to the acetabulum.
4. If the hip is dislocated, the tip of the trochanter lies above Nélaton's line, which extends from the anterior superior spine of the ilium to the ischial tuberosity.

In all cases suspected of having a dislocated hip a roentgenogram should be made of the pelvis and both hips; when properly made it will reveal any existing dislocation.

Treatment of a congenitally dislocated hip is most successful when the condition is recognized in the early months of infancy. Gradually increasing abduction of the hips by the use of the pillows designed by Putti or Frejka usually effects a reduction of the dislocation within a few months. With this method no anesthetic is required.

The dislocation may be overlooked until the child begins to walk with a limp. If the dislocation is unilateral, there is a peculiar lurch or giving-down at the hip at each step when the body weight is borne on it. If there is a bilateral dislocation of the hips, the child waddles from side to side in walking, the hips appear to be high and the trunk shortened because of the extreme lordosis (Fig. 136) which is always present, and when the child lies supine on the table with the legs parallel, the upper thighs are separated more than normal and the perineum appears to be widened.

The result of the Trendelenburg test for stability of the hip is positive on the side of the dislocation. When the child stands with his back to the examiner and raises the foot of the uninvolved side from the floor, the pelvis on that side is seen to sag downwards instead of

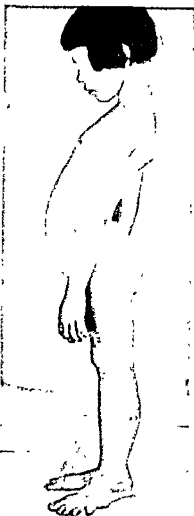


*Figure 136* Bilateral congenital dislocation of the hip Note extreme lumbar lordosis. (Courtesy of Pullen, R.: Applied Physical Diagnosis. Philadelphia, W. B Saunders Co, 1944)

rising upwards as it would if the opposite hip were stable and not dislocated.

Treatment of the dislocated hip after infancy is increasingly difficult and less satisfactory as the child grows older. Manipulation and reduction under anesthesia followed by prolonged fixation in plaster is usually employed for children under five years of age. Some under five years and most of those who are older require reduction by operative procedures, and the results often are imperfect.

*Congenital Pseudoarthrosis of Tibia and Fibula.* In this condition there is a fracture in the middle third of the tibia and fibula with nonunion. The bone ends are pointed and no callus is laid down.

*Congenital flat foot* is a true pes planus present at birth. The feet are very relaxed, assume the calcaneovalgus position and have a prominence under the middle of the foot (Fig. 137).

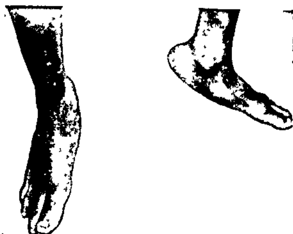


*Figure 137* Congenital flatfeet in adult. (Courtesy of Pullen, R.: Applied Physical Diagnosis. Philadelphia, W. B. Saunders Co., 1944.)

*Congenital metatarsus varus* may be thought of as being a "third of a clubfoot." There is an adduction and inversion deformity of the fore part of the foot.

*Arthrogryposis Multiplex Congenita.* Multiple joints show deformities and limited movements from soft tissue contractures. The muscles appear as a mass of fibrofatty material that contains some remnants of degenerating muscle fibers.

*Congenital clubfoot* (Fig. 138) is the

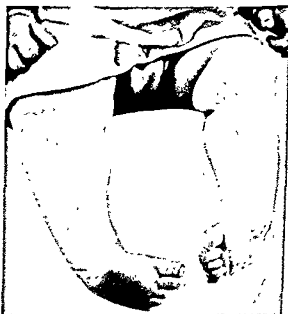


*Figure 138.* Congenital bilateral clubfeet in infant. (Courtesy of Pullen, R.: Applied Physical Diagnosis. Philadelphia, W. B Saunders Co, 1944)

commonest of all deformities. There are three components of the deformity: (1) adduction of the forefoot, (2) inversion of the entire foot and (3) equinus of the forefoot and ankle. The deformity tends to increase and become more fixed with growth and weight bearing. Therefore, it is important to begin treatment at the fourth to sixth week of life.

Correction in babies can usually be accomplished by gradual stretching at intervals of one to two weeks with repeated applications of plaster to maintain the improved position. These procedures are carried out without use of an anesthetic and frequently are done in a physician's office or in an out-patient clinic. Nevertheless, it is a complicated problem which requires patience, skill, good judgment and orthopedic experience. It is unwise for one who may have a limited experience in plaster work with fractures to undertake correction of the clubfoot.

Some cases of clubfoot that are resistant to gradual stretching, some that recur after incomplete correction and others that have had no treatment until the child is several years old will require operative measures in addition to correction in plaster. Most of those patients in whom the deformity is well corrected during infancy will have feet that appear normal and function well, whereas those whose final correction must be accomplished with the aid of surgical procedures usually have some stiffness and slight residual deformity.

*Chapter 14*

# Injuries

*By Guy A. Caldwell and Harry D. Morris*

## CERVICAL REGION

Injuries to the cervical spine consist of fractures and fracture-dislocations with or without injury of the spinal cord, unilateral or bilateral dislocations, and articular sprains. Muscular injuries are generally strains, contusions or lacerations.

### STRAINS AND SPRAINS AND WHIPLASH INJURY

***Strains and Sprains.*** A *sprain* of the neck implies overstretching or rupture of the ligaments that join and support the cervical vertebrae and their articulations. The term *strain* is applicable to the cervical muscles only when they have been overtaxed or overstretched. The cause may be the same in either event, namely, a violent wrench of the head from one side to the other, as sustained by a child who has fallen out of bed on his head or by a football player who is tackled about the neck.

***Whiplash Injury.*** Whiplash injuries are becoming increasingly common. Usually the victim is sitting relaxed in a stationary automobile that is struck suddenly from behind by an approaching vehicle. The impact causes the patient's body to be jerked forward with the back of the seat. Inertia causes the unsupported head to fall violently backward in relation to the body. The recoil from the impact then throws the unsupported head violently forward, completing the whiplash action. In a minor collision, this may cause only a mild sprain of the ligaments of the cervical vertebrae and possibly a strain of the muscles of the neck and shoulders. Seldom is the force sufficient to cause a vertebral fracture or dislocation. Frequently, the symptoms are out of proportion to the physical findings and persist for many months with little or no objective signs remaining on examination. This injury has been the subject of much medicolegal controversy and litigation. For this reason, most surgeons who treat these patients are anxious to discard the term "whiplash injury," which is merely a description of the mechanism of injury and does not denote the actual injury produced to the tissues. An anatomic or pathologic designation of the injury received would be much better. Treatment of this condition is similar to that of strains and sprains of the cervical region.

***Treatment of Strains and Sprains and Whiplash Injury.*** A diagnosis of strain or sprain of the neck should not be made until a diagnosis of fracture or dislocation has been excluded by roentgenography. Severe sprains will be relieved more promptly if the patient is kept in bed with traction applied to the neck by means of a head halter for a few days (Fig. 139). A hot water bottle behind the neck and mild sedatives should be provided. After the acute soreness and tenderness have disappeared, the patient may be ambulatory, and, for several days thereafter, hot fomentations or radiant heat should be applied to the neck for 20 to 30 minutes twice daily, followed by massage over the muscles for 10 minutes. Occasionally, it is necessary for the patient to wear a plastic or felt Thomas collar during convalescence in order to support the neck and relieve the aching. Muscle relaxants, such as Mephenesin or Chlorzoxazone, are helpful in controlling muscle spasm. Meprobamate has proved to be an extremely satisfactory muscle relaxant in cervical injuries and relieves the patient's anxiety regarding his condition.

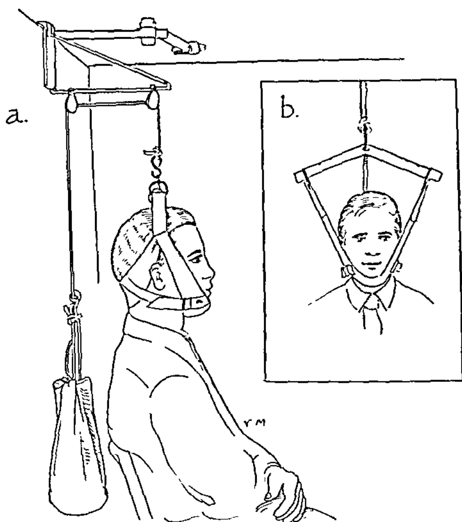



*Figure 139.* *a*, Cervical traction with "Sayre" head halter, overhead bracket attached to door for home or office use. *b*, Front view. Spreader band prevents pressure of halter on ears.

### FRACTURES AND FRACTURE-DISLOCATIONS

Crushed fracture of the body of a cervical vertebra may result from falling on the head, diving in shallow water, or being thrown against the top of an automobile. In such accidents, the head is forced downward and forward, and the neck is forcibly flexed. The force is usually maximal at the level of the third, fourth or fifth cervical vertebra, one of which is crushed. The patient immediately feels severe pain at the level of the injury, with stiffness and spasm of the cervical muscles. Since the spinal canal is relatively large at this level, the cord often escapes injury, but temporary pain and weakness of one or both arms may occur.

Head-on collision of two automobiles may result in a crushed fracture of the body of one vertebra with forward dislocation of the vertebra above. In these cases the displacement is much greater, and the spinal cord is likely to be crushed, with immediate partial or complete paralysis of all parts below the level of the injury.

Patients with suspected fracture or fracture-dislocation of the cervical spine should be transported immediately to a hospital, as these injuries are severe and serious complications may develop. Careful handling of these patients at the site of the accident and in transit is extremely important. Those who have a possible fracture but can move arms and legs freely should be protected from further displacement and possible damage to the spinal cord, and those with partial or complete paralysis may have some chance of recovery if the cord is not further damaged by undue motion of the head or neck. To prevent further

displacement and injury to the cord someone should grasp the head and maintain traction in a straight line while others lift and move the patient onto a stretcher. Continuous manual traction should be maintained until the patient reaches the hospital or until protection can be afforded by a temporary cervical collar.

Roentgenograms should always include a view of the odontoid process, taken through the open mouth, if possible, and in the lateral roentgenogram the shoulders should be pulled distalward by traction on the arms so that the entire seventh cervical vertebra can be visualized and is not obscured by the overlapping shoulder shadows.

Treatment of fractures or fracture-dislocations of the cervical spine generally requires skeletal traction by means of skull tongs. Hospitalization is mandatory.

### Dislocations of the Cervical Spine

*Traumatic Dislocations.* Unilateral or bilateral dislocations of the cervical spine may result from sudden twists or jerks, and occasionally from "whiplash" injuries. Such dislocations often occur as a result of a head-on collision, loss of footing, a fall, or sudden release of a wrench. Most unilateral or bilateral dislocations do not injure the spinal cord.

Such injuries cause pain and localized tenderness at the level of the dislocation, and generalized spasm of the cervical muscles with limitation of all cervical movements. In unilateral dislocations, the head assumes the same position as in torticollis. Pain caused by pressure on the nerve roots at the level of injury may extend down the arm. The displacement will be demonstrated in anterior, posterior and lateral roentgenograms.

Cervical dislocations are treated by skeletal traction with Crutchfield tongs or by manipulation under anesthesia, both of which are hospital procedures.

*Non-traumatic Dislocations of the Atlanto-axial Joint.* In children from 6 to 12 years of age, an apparent torticollis occasionally develops after an infection of the upper respiratory tract. Good lateral roentgenograms of the two upper cervical vertebrae will reveal anterior displacement of the arch of the atlas in relation to the odontoid process and overlapping of the lateral articular facets.

Traction applied to the head by halter usually accomplishes reduction in a few days. A plaster jacket extending up to the chin and occiput should be worn for three or four weeks. Occasionally, use of a commercial Thomas collar or cervical brace will suffice.

### Thoracic and Dorsal Region

*Contusions of the Trunk.* Direct blows over the thorax, abdomen and back may produce nothing more than stiffness and soreness of the structures directly affected, may cause extensive ecchymosis and hemorrhage into the surrounding tissues or may seriously injure some of the viscera in the chest or abdomen. All severe contusions should be regarded as potentially serious, a detailed history should be obtained, a thorough examination including roentgenograms as indicated should be made, and the patient should be kept under observation for one or two days. In some cases a subcutaneous or subfascial hematoma may develop rapidly or slowly, and when large should be aspirated under aseptic precautions. When an extensive hematoma develops rapidly or recurs after aspiration and the application of pressure, it should be incised, evacuated, the bleeding points ligated and a pressure dressing applied. Some degree of shock frequently accompanies severe contusions even when there is no visceral injury. Symptoms of shock such as weakness, pallor, nausea and a rapid pulse suggest the need for rest, sedation and perhaps administration of fluids.

*Contusions of the Thorax.* Severe blows over the chest may be expected to produce fracture of one or more ribs and possibly injury to the lungs or heart. In such cases the symptoms of the fractured ribs dominate the clinical picture but there will also be signs and symptoms of respiratory or circulatory em-

barrassment combined with shock. Such cases should be recognized promptly as being serious, and referred to a hospital for accurate diagnosis and immediate treatment.

*Contusions of the Breast in Women.* These are quite painful but seldom serious. Such injuries are not considered causative factors of cancer of the breast. If the breast is swollen and discolored from effused blood, it will be made more comfortable by application of a binder which elevates the breast and maintains moderate pressure over it.

*Contusions of the Abdomen and Flank.* Severe bruises of the abdominal wall are frequently accompanied by intense pain and muscular rigidity which resembles that caused by visceral injury. Diagnosis of intra-abdominal injury cannot be made from the presence of abdominal pain and muscular rigidity alone. Elevation of the pulse rate, leukocytosis, presence of shifting dullness, vomiting, pallor, low blood pressure and the roentgenographic demonstration of pneumoperitoneum will help determine the need for surgical intervention. Aspiration of the peritoneal cavity by means of the Potter needle is frequently of value in demonstrating intra-abdominal injury.

Severe contusions of the flank may injure the kidney to some extent. If the kidney has been bruised or ruptured, in addition to the local signs of injury and the general symptoms of shock, blood will be found in the urine. Simple contusions of the kidney require no treatment other than rest but the more extensive injuries may require prompt surgical measures for relief.

*Contusions of the Back.* Direct, hard blows over the large muscles of the back result in stiffness, soreness and pain accompanying back movements. Tenderness will be apparent over the bruised areas but not over bony prominences. However, roentgenograms should be made to eliminate the possibility of fracture of one or more transverse processes. Bed rest, sedatives, external heat and massage are indicated for relief in the more severe cases.

*Rupture of Muscles.* Muscles of the trunk that are occasionally ruptured are the rectus abdominis, the pectoralis, the serratus magnus and the psoas. In general, the causative factor is a quick, violent effort involving principally the affected muscle. Rupture of muscles of the back as a result of muscular effort is unlikely and has not been recognized. The structural and ligamentous checks on the spinal movements probably prevent overstretching and rupture of muscles. Relatively little bleeding occurs from the torn muscle ends but sometimes sizable vessels are torn within the muscle sheath, resulting in the formation of a large hematoma. Immediately after injury the patient feels sharp pain at the site of rupture and weakness upon attempting the movement that produced the rupture. Subsequent swelling, soreness and stiffness of the surrounding muscles are to be expected.

*Treatment* requires operative exposure of the torn muscle and approximation of the ends by mattress sutures. Best results are obtained if the muscles are repaired within a few days after injury. If done after weeks or months scar tissue must be removed and approximation becomes difficult because the muscle ends have retracted and shortened.

*Fractures of the Dorsal Spine.* Fractures and fracture dislocations of the first ten dorsal vertebrae are much less frequent than those in the cervical or lumbar region because of the relatively limited movements of this part of the spine to which the rib cage is affixed. However, the spinal canal is smaller in the dorsal region and paralysis is therefore more likely to result from crushing of the vertebral body.

Restoration of the anterior portion of the vertebral body to its normal height by hyperextension is prevented by immobility of this portion of the spine. Therefore, treatment should be directed towards rest and fixation during the early weeks and later towards exercises to improve the strength of the supporting musculature. At first, rest on a hard bed or Bradford frame is indicated and may be supplemented by traction by

means of a head halter if there is considerable pain. After two to four weeks a plaster jacket may be applied with the spine extended by traction; the plaster should be carried up over the shoulders but should not include the neck. The patient may then be ambulatory and may carry on with exercises to strengthen dorsal and cervical muscles for two to three months longer.

*Fractures of Ribs.* Fractures of ribs are usually caused by direct blows but occasionally occur as a result of violent coughing. Only a single rib might be fractured or several contiguous ones on the same side might be broken. Breathing causes a sharp pain, partly as a result of grating of the fractured rib fragments and partly from the inflamed lining of pleura adjacent to the injured ribs. Linear fractures through ribs are not easily identified in roentgenograms of the thorax. Fractures of the anterior portions of the ribs may not be visualized roentgenographically because these portions are not dense enough. Therefore, a negative report from the roentgenologist does not preclude the presence of a fracture which may be identified by local pain and tenderness.

Complications of multiple fractures resulting from a severe crushing injury are common. These may be associated as hemothorax, puncture of the lung with emphysema or pneumothorax, pulmonary hemorrhage and pneumonia. At times there are also abdominal complications referable to rupture of the liver or spleen. Treatment of such complications is most urgent and overshadows treatment of the rib fracture.

If only one, two or three ribs are fractured and there is little displacement or injury to deeper structures, treatment is directed toward relief of pain. This may be accomplished by (1) limiting the thoracic excursion with an external supportive dressing (Fig. 140) and (2) intercostal nerve blocks with procaine hydrochloride. The latter procedure is particularly indicated in elderly people with multiple fractures.

A simple supportive dressing is a broad canvas belt that can be buckled tightly around the thoracic wall and is kept at the right level by a shoulder strap (Fig. 141). These belts are available at most surgical supply houses. The same effect may be obtained by completely encircling the chest with overlapping strips of 2-inch adhesive applied over a layer of flannel. Shoulder straps should be added to prevent this dressing from slipping downwards. Adhesive strips may be applied directly to the skin provided they do not encircle the chest but extend only around three-

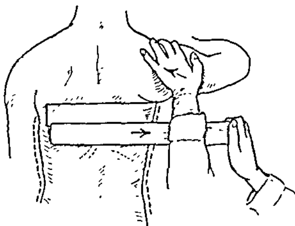


*Figure 140.* Method of strapping the chest for a fracture of the rib. The straps are applied very firmly from the top downward while the patient holds his breath in exhalation. The authors usually prefer the rib splint (Fig 141) or tight encirclement of the chest with strong muslin bandages to strapping in rib fractures

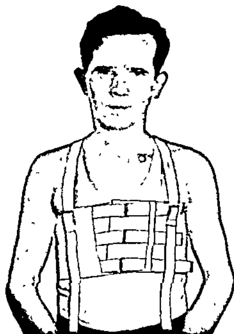


*Figure 141.* Rib splint. This is an adjustable canvas belt with shoulder straps.

fourths of the circumference. Each strip should be applied when the patient has fully exhaled and the chest is therefore reduced in size.

If one of the dressings for external support fails to give adequate relief during the first few days when pain is severe, intercostal nerve block should be considered. From 2 to 4 cc. of 1 or 2 per cent solution of procaine hydrochloride should be injected into each intercostal space posterior to the actual sites of fracture. Greater relief is obtained if several nerves are injected above and below the injured ribs. The needle should be inserted to contact the rib above the space to be infiltrated and its point then carried gently downward following the outer aspect of the rib to its lower border, then to the interosseous space. As the needle is felt to reach the lowermost edge of the rib, an aspiration test should be carried out with the needle rotated in two planes in order to make certain that an intercostal vessel has not been punctured. Care should be taken to avoid inserting the needle far enough to penetrate the pleura or the lung. A sudden coughing spasm or a bitter taste in the patient's mouth suggests penetration of the pleura and lung and the needle should be immediately withdrawn. This technique is illustrated in Chapter 4.

*Costal Cartilage Injuries.* Severe blows to the front or sides of the lower part of the thorax may injure the costal cartilages without fracturing the ribs. The cartilage itself may be fractured, or it may be separated at its junction with the rib, the sternum or an adjoining cartilage. Such separations cannot be visualized in the roentgenogram but can usually be detected by palpation. They respond to immobilization of the chest by bandages or adhesive strapping but often require six to eight weeks for recovery. In some cases no definite fracture can be located but the costal cartilages are generally sore and tender from being bruised and forcibly sprung; these require support as if they were actually fractured.

*Fracture of the Sternum.* This is a rare fracture that usually occurs at or near the junction of the manubrium and gladiolus and may show no displacement. In a few cases the lower fragment will be depressed. The displacement can usually be corrected by hyperextension of the dorsal and cervical spine over the edge of a bed or table, but if this fails open reduction may be done. A light binder is adequate fixation for linear fractures or after reduction of displaced fractures and should be continued for two to three weeks.

## UPPER EXTREMITY

### Fractures and Dislocations

***Dislocations of the Sternoclavicular Joint.*** These occur infrequently as a result of indirect violence. They are characterized by moderate pain, swelling and tenderness localized to the sternoclavicular articulation. Movements of the shoulder girdle aggravate the discomfort and produce a slipping sensation which is felt by the patient and by the examiner's palpating fingers. The usual displacement of the inner end of the clavicle is forward and upward on the sternum but sometimes it is downward or even posterior to the sternum and may be visualized in carefully made roentgenograms.

The dislocation may be reduced by pulling the shoulders upwards and backwards and at the same time making counterpressure forwards between the scapulas. The corrected position may be maintained by a clavicular cross or a plaster yoke applied as for fracture of the clavicle. The splinting should be continued for four or five weeks and it is often necessary to renew the splinting several times during this period. Results from this treatment are not uniformly good because the articular disk may be torn and displaced in such a way as to prevent accurate reseating of the inner end of the clavicle. However, despite incomplete reduction and persistence of a visible and palpable enlargement of the joint, the functional result is frequently satisfactory. Therefore, operative intervention is justified only when there is persistent and disabling pain resulting

from use of the arm and shoulder. Operative repair is difficult and not always satisfactory and resection of the inner end of the clavicle may be finally required.

*Acromioclavicular Separations* (upward dislocation of the acromial end of the clavicle). These injuries are caused by a fall or a blow on the point of the shoulder which forces the acromium downwards. They are fairly common in younger men, especially among football players The outer end of the clavicle shifts upwards, and appears more or less prominent depending upon the extent of rupture of the coracoclavicular ligaments and the capsule of the acromioclavicular joint. In the recently injured, swelling may be observed and tenderness may be elicited over the acromioclavicular joint and the coracoclavicular ligaments.

Reduction may be accomplished by downward pressure on the outer end of the clavicle at the same time that upward pressure is made on the flexed elbow. If there is but slight upward displacement of the end of the clavicle, the reduction may be maintained adequately by adhesive strapping applied as shown in the accompanying illustration. It should be renewed from time to time for a period of three to four weeks. However, considerable upward displacement of the clavicle implies complete rupture of the coracoclavicular ligaments and operative repair is usually necessary to prevent disabling sequelae.

*Fractures of the Scapula.* These include fractures of the body, neck and coracoid process. Crushing injuries received in a fall from a height or in an automobile collision may comminute the blade of the scapula, or longitudinal splits may occur throughout the entire length. Little if any displacement occurs in this injury and reduction is not necessary. Adhesive strapping across the shoulder and over the back of the scapula to the level of the patient's waist will furnish the necessary immobilization.

Fractures of the neck of the scapula result in separation of the glenoid fossa from the body of the scapula, but the glenoid fragment can generally be con trolled by manipulation or abduction of the arm. In the young patient, treatment by means of abduction of the arm and body cast is usually sufficient, and exercise of the arm should be begun in five to seven days by removal of the top of the arm and shoulder portion of the cast. In older patients slight malunion is preferable to prolonged immobilization, and support of the arm in a sling followed by active early circumduction exercises, as described for fractures of the upper extremity of the humerus, will produce satisfactory functional results. Continuous traction is rarely necessary.

*Fractures of the coracoid process,* if displaced owing to pull of the short head of the biceps and coracobrachialis muscles, may lead to some continued disability unless the fragment is replaced surgically. Incomplete fractures will generally unite satisfactorily without specific treatment. Special oblique roentgenograms are necessary at times to show this lesion, and persistent tenderness over the coracoid process is an indication for these special views.

*Fractures of the Clavicle.* These fractures are common, especially among children. They are usually due to a fall on the outstretched arm or on the shoulder but may be caused by a direct blow. In young children the fracture is usually of the greenstick type with angulation but no overriding (Fig. 142). In older children and adults the fracture usually occurs at the junction of the middle and outer thirds and is complete with displacement (Fig. 143). The weight of the arm and shoulder drag the outer fragment downward, forward and medially while spasm of the sternocleidomastoid muscle tends to pull the inner fragment upward and backward. Severe injuries may produce comminuted fractures with bizarre displacements and, rarely, compound or open fractures. These may be complicated by injuries of adjacent nerves or vessels and may require open reduction and some type of internal fixation. However, most simple fractures of the clavicle may be reduced without anesthetization and splinted by one of



*Figure 142.* Greenstick fracture of the clavicle.



*Figure 143.* Complete fracture of the clavicle; good position.

several methods, and will unite with good functional results even when there is some overriding or angulation.

*Treatment.* Reduction is accomplished by forcing the shoulders upward, outward and backward with the patient in the sitting position and the surgeon working from behind, keeping his knee against the back between the shoulders for counter pressure. In older patients, the reduction is expedited by injection of 5 to 10 cc. of a 1 per cent solution of procaine hydrochloride into the hematoma at the site of the fracture. In some cases reduction is better accomplished by allowing the patient to lie on his back on a narrow table or board with a sandbag between his scapulae and his arms hanging over the sides of the table.

In young children the reduction can usually be maintained with a figure-of-8 bandage applied over thick pads in front



*Figure 144.* Application of figure-of-8 bandage for fracture of the clavicle. (Watson-Jones, R.: Fractures and Other Bone and Joint Injuries.)

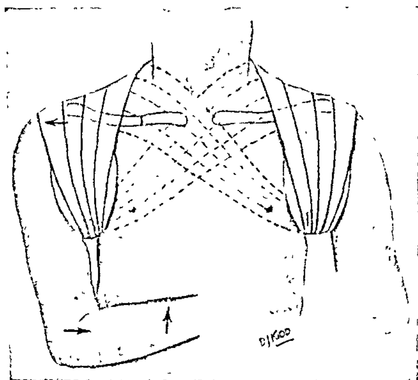


*Figure 145.* The bandage pulls the outer fragment backwards and upwards, and the weight of the arm over the axillary pad maintains distraction from the midline. (Watson-Jones, R.: Fractures and Other Bone and Joint Injuries.)

of the shoulder and in the axillae (Figs. 144 and 145). The fractures in older patients are better controlled with some modification of the T splint. The splint or bandage should be worn by young children for three weeks but by older children and adults for four to six weeks.

***Dislocation of the Shoulder.*** Acute dislocation of the shoulder is most often the result of the arm being forced into abduction. The head of the humerus ruptures the inferior portion of the capsule, which is weaker in this region, and may occupy a position anterior, inferior or posterior to the glenoid fossa. Inspection reveals loss of the rounded contour of the shoulder. The patient is in severe pain. He may be holding the hand and supporting the forearm, the injured arm being carried close to the trunk. Any attempt to move the arm is resisted. If there is not too much swelling, the head



*Figure 146.* Dislocation of the shoulder with fracture of the greater tuberosity of the humerus



[illegible] the greater tuberosity of the humerus.

of the humerus may be felt in an abnormal position, and it is impossible to place the hand of the injured extremity on the opposite shoulder. Roentgenograms (Fig. 146) should always be made in dislocations or suspected dislocations in order to exclude associated fractures of the head or neck of the humerus. Tactile sensation and motor function of the hand should be tested and recorded before reduction as a medicolegal precaution, especially in compensation cases. Sometimes the brachial plexus is injured or compressed by the dislocated humeral head.

Reduction should be performed immediately after injury in order to relieve pain, and often can be accomplished with adequate narcosis instead of a generalized anesthetic. However, after muscle spasm and swelling occur, a general anesthetic should always be used when the reduction is performed in order to prevent further injury to the musculature and ligamentous structures about the shoulder. Reduction in the early

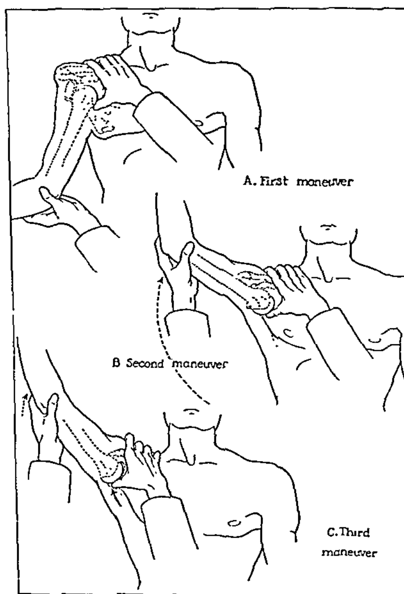



*Figure 148.* Reduction of shoulder dislocation. *A*, First maneuver: the patient supine, the surgeon's right hand is braced against the shoulder, while the thumb fixes the humeral head; *B*, second maneuver: the patient's dislocated arm is abducted in external rotation, the thumb pressure against the humeral head is still maintained; *C*, third maneuver: with the arm in the completely abducted position, the surgeon's thumb gently pushes the humeral head over the glenoid ridge into the fossa. (Milch, H.: Surgery, *3*:732, 1938)

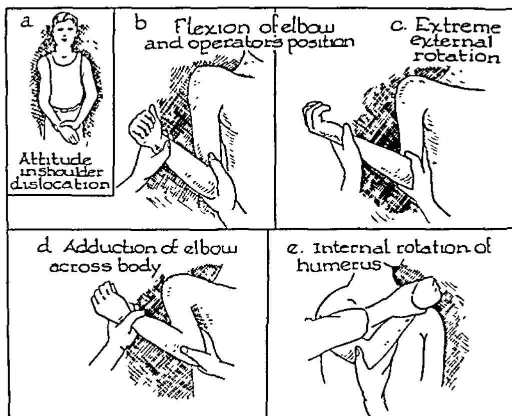



*Figure 149.* The Kocher maneuver for reduction of dislocated shoulder.

cases may be accomplished readily by any of the standard maneuvers (Fig. 148), such as the Kocher procedure (Fig. 149), traction with the heel in the axilla, or direct traction and abduction with upward and backward pressure on the head of the humerus. This last method probably produces the least damage to the margin of the glenoid fossa and capsule. Roentgenograms should be made following reduction to see that it is complete and that the humeral head is in proper position (Fig. 147). Approximately three weeks are required to repair the defect in the capsule completely, and partial immobilization with Velpeau's bandage or with a sling and swathe should be mandatory during this period to prevent recurrent or habitual dislocation, which is a serious disability. Treatment after this period of immobilization is the same as that for fractures of the upper extremity of the humerus.

*Dislocation of the Elbow.* Dislocation of the elbow results from direct trauma or a fall on the extended arm and is frequently mistaken for a supracondylar fracture. Roentgenograms should be made. If seen before pronounced muscle spasm and swelling, these dislocations may be reduced with narcosis or injection of procaine into the joint. The manipulative procedure is by hyperextension, traction and countertraction. By this procedure the coracoid process is first disengaged from behind the trochlear surface of the humerus and drawn forward to its natural position.

Splinting after reduction is essential because the periosteum has frequently been stripped away from the lower end of the humerus together with the capsule, and continued motion will result in progressive stiffness due to myositis ossificans. This complication can best be prevented by immobilization of the elbow at a right angle for two weeks to permit arrest of hemorrhage, absorption of exudate and healing of soft parts. Active elbow motion should then gradually be resumed. Passive stretching and carrying of heavy weights should never be used in the convalescent treatment of elbow injuries.

In small children traction on the extended arm by the parent, as in lifting

the child, occasionally results in subluxation of the radial head and the child refuses to move the elbow after such an incident. Supination and pronation with a little traction usually reduces this subluxation and allows the child to resume active use of the extremity without pain.

*Fractures of the Upper Extremity of the Humerus.* Fractures of the upper extremity of the humerus that can be treated in the office include fractures of the anatomic and surgical neck and greater tuberosity. These usually occur in an elderly person who has fallen on his shoulder or upon his outstretched hand. Often the fracture is impacted and there is little or no displacement. Roentgenograms made in two planes are required to exclude a fracture with dislocation of the head of the humerus—a condition that would require operative care. Nonunion seldom occurs because the blood supply in this portion of the humerus is abundant.

Treatment is planned to obtain a maximum range of motion in the shoulder joint as soon as possible. Anesthesia for reduction is not necessary since anatomic restoration of the fragments is not essential for good function and early motion can usually be instituted because the fragments are often impacted. The shoulder can be immobilized by placing a pad between the arm and the chest wall and a sling under the flexed forearm, and then applying a circular bandage about the arm and thorax.

A day or two after injury, radiant heat and gentle massage may be employed to disperse the swelling and hematoma and by the fourth or fifth day the bandage and sling may be removed long enough for the patient to take relaxed circumduction exercises, as follows. The patient leans forward until his trunk is almost at a right angle to his hips, and steadies himself in this position by grasping the end of a table or bed with one hand. The affected arm is allowed to hang straight down with the muscles of the shoulder and arm completely relaxed, so that the arm simply dangles. A sandbag or a shotbag weighing from 2 to 5 pounds should be strapped to the wrist. By swaying the body and exerting the shoulder muscles ever so slightly, the patient can swing his arm in a wide arc and make a complete circle, or he can swing it to and fro and from side to side. Performance of these movements for three to five minutes serves to relax tense muscles, increase joint motion and prevent the formation of adhesions. As the soreness and pain diminish these exercises may be repeated several times daily. After three weeks the sling may be discarded and the patient encouraged to voluntarily abduct and externally rotate his arm as far as possible. As a rule the patient may be allowed almost unrestricted use of the arm within six weeks.

*Fractures of the Shaft of the Humerus.* Simple complete fractures of the shaft of the humerus without displacement in adults and greenstick fractures in children can be treated by the use of a hanging cast (Fig. 150), as popularized by Caldwell.[1] He described the method as follows: "A plaster cast is applied from the axilla to the hand over a stockinette.

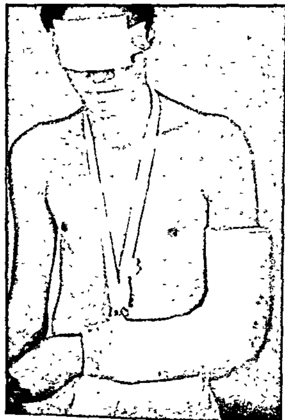


*Figure 150.* Hanging cast. (Caldwell, J. A: Surg., Gynec. & Obst., *70*:421, 1940)

The elbow is flexed 90 degrees; the forearm is in midpronation. A wire loop is incorporated in the cast just above the base of the thumb and through this a piece of bandage is threaded which passes about the patient's neck. We instituted the use of this loop when we found that patients would move the sling up the forearm toward the elbow in order to relieve the pull on the shoulder. . . . Patients are cautioned not to rest the elbows on chair arms or other objects and to sleep with their shoulders well elevated. After 7 to 10 days the patient is instructed to rotate the humerus within limits of comfort and in two weeks he is directed to abduct his arm as far as he can comfortably. Usually in four weeks the cast can be removed and a sling substituted, and movements of rotation, swinging and abduction can be amplified."

*Fractures of the Lower Extremity of the Humerus.* Fissure fractures of the lower end of the humerus without displacement and undisplaced incomplete supracondylar fractures can be treated in the office by early immobilization in a posterior plaster splint with the elbow at a right angle. Displaced or supracondylar fractures of the humerus, which occur principally in children after falls upon the hand, are generally accompanied by extensive swelling and circulatory disturbance of the extremity. These require hospitalization for at least 24 hours, reduction under general anesthesia, and careful observation of the circulation for 24 to 48 hours afterwards because of the danger of Volkmann's ischemic contracture.

*Fractures of the Olecranon.* Most fractures of the olecranon are caused by a fall on the flexed elbow. If the fracture is incomplete and there is no displacement, adequate immobilization may be obtained by use of a posterior molded plaster splint with the elbow flexed at a right angle. If the fracture is complete but with no separation of fragments, the elbow should be immobilized in extension with anterior and posterior molded plaster splints. After two weeks the splints can usually be removed for 20 minutes each day and the patient directed to move the elbow gently within the limit of producing pain. The splints should be reapplied after each period of exercise. If the fragments of the olecranon fracture are separated or comminuted, it is imperative to perform open reduction and internal fixation.

*Fracture of the Head of the Radius.* In children this fracture is usually incomplete and impacted with slight angulation. There may be some swelling about the radial head. In such cases reduction is unnecessary. Simple immobilization of the elbow at right angles until the swelling has disappeared, and then gradual use of the part, will suffice. (Detached and displaced fractures of the radial head in children require open reduction and fixation with sutures but in such cases the head should never be removed.) In adults a simple fissure or small marginal fracture may be treated by use of a sling only, or of a posterior molded splint with the elbow at 90 degree flexion. As soon as the swelling and tenderness have subsided, the splint or sling should be removed for short periods each day and the patient directed gradually to flex and extend his elbow and to pronate and supinate his forearm. Injection of procaine into the joint will permit earlier resumption of active motion.

Comminuted fractures of the radial head with displacement of fragments in the elbow joint, and large marginal or pie-crust fractures involving a large part of the circumference of the head, should be treated by excision of the entire head. The decision to operate should be made early, as delayed excision always results in poorer function than if the operation is performed shortly after the injury.

*Fracture of Shaft of Radius and Ulna.* Incomplete fractures of either radius or ulna (Fig. 151) or complete fractures without appreciable displacement, which occur principally in children, can be treated without reduction by application of a circular plaster cast. The plaster should extend from the metacarpopha-



*Figure 151.* Subperiosteal fracture of the shaft of the ulna.

langeal joint to the upper portion of the humerus with the elbow in flexion and the forearm in midpronation. Immobilization of the elbow is necessary to prevent rotation of the forearm. Care should be taken to cut the plaster away from the palm and about the thumb in order to permit complete flexion of the metacarpophalangeal and interphalangeal joints.

Greenstick fractures of the shaft of the radius and ulna with angulation are often seen in children. Occasionally such greenstick fractures can be manipulated without anesthesia, but apprehensive children with nervous parents should have a general anesthetic. The greenstick fracture should be reduced by increasing the angulation gradually until the bone is broken across completely, care being exercised to avoid tearing the periosteal tube additionally. By making the fracture complete there is no "spring" left in the unbroken portion of the bone, the fragments fall into alignment readily and the untorn portion of the periosteum retains good apposition of the fragments. Plaster should then be applied from the metacarpophalangeal joints to the upper part of the arm as previously described.

*Fracture of Distal Portion of Radius (Colles' Fracture)* (Figs. 152 and 153). Incomplete or undisplaced fractures that do not appreciably alter the angle of the articular surface of the radius may be splinted in plaster without reduction. The plaster should be applied from the metacarpophalangeal joints up to, but not including, the elbow with the wrist in slight dorsiflexion. The plaster should be trimmed to allow complete flexion at the metacarpophalangeal and interphalangeal joints.

Elderly patients with such fractures should not wear a sling and should exercise the elbow and shoulder joints daily, putting them through a complete range of motion several times in order to prevent stiffness of these joints which is more disabling than the untreated fracture at the wrist would be. All Colles' fractures with alteration of the articular angle of the radius or disruption of the radio-ulnar joint require a general anesthetic or brachial block in order to

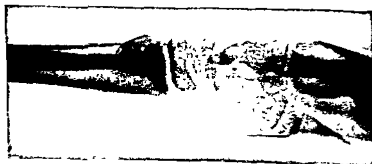


*Figure 152.* Impacted fracture of the lower end of the radius, "sprain fracture."

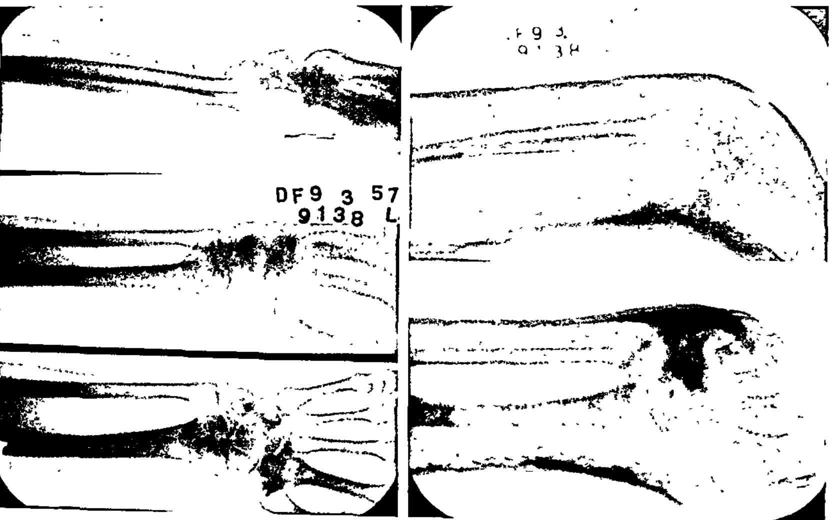



*Figure 153.* Colles' fracture. *A.* Roentgenogram of distal portion of radius (Colles' fracture). Note dorsal tilt (silver fork deformity) and radial deviation of distal fragment. *B.* Same fracture after reduction and plaster immobilization. Forward tilt of articular surface of radius has been restored. The hand is ulnar deviated and wrist flexed.

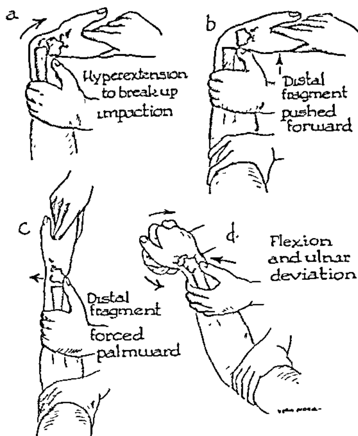



*Figure 154.* Method of reduction by manipulation of fracture of distal end of radius (Colles' fracture). Arrows indicate direction of traction.

break up the impaction and obtain adequate reduction (Fig. 154).

***Fracture and Dislocation of Carpal Bones.*** *Navicular fracture* is usually incurred by falling on the outstretched hand. As in a Colles' fracture, the hand is usually radially deviated at the time of the injury. Clinical examination reveals swelling of the wrist, acute tenderness localized to the anatomic snuffbox and pain on abduction of the hand. Movements of the wrist are limited and painful, and pain is produced in the region of the navicular bone with axial pressure on the first and second metacarpal bones. Roentgenograms taken as anterior, posterior, lateral and special oblique views are generally necessary to reveal the navicular fracture. These injuries are frequently diagnosed originally as sprains of the wrist because initial x-ray examination may fail to reveal a fracture line. Therefore, if symptoms persist after ten days or two weeks, additional roentgenograms should be made which then will reveal definite evidence of fracture if present.

Treatment of recent fractures consists of immobilization in a well-fitted circular plaster cast extending from the elbow to the distal palmar crease with the thumb extended and the hand dorsally flexed and adducted (Fig. 155). Immobilization should be complete and continuous until roentgenograms reveal evidence of consolidation of the fracture, which may require from as little as eight weeks to as much as nine months. Several authors report union in 95 per cent of cases when continuous immobilization has been maintained for an adequate period of time. Neglect of initial immobilization or insufficient immobilization will result in nonunion and will require subsequent excision or grafting of the ununited fragments.

***Dislocation of the Lunate Bone.*** Palmar dislocation of the carpal lunate, the third most common injury in the wrist, is incurred by falling on a hyperex-



*Figure 155.* Type of cast employed in fractures of the carpal scaphoid, showing method of holding the hand while the plaster is drying Note that the splint is carried to the metacarpophalangeal joints of the fingers and to the level of the middle of the thumb nail. No pressure is put on the tip of the thumb. (Soto-Hall, R: J.A.M.A, *129*.335, 1945 This article gives the methods of reduction of fractures)

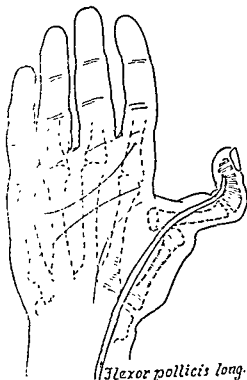



*Figure 156.* Diagrammatic representation of dislocation of the thumb. The proximal phalanx may be engaged behind the flexor pollicis longus tendon.

tended wrist. Deformity is minimal because of the thick transverse volar carpal ligament. The patient complains of inability to flex and extend the fingers, and signs of median nerve pressure are almost always present. Lateral roentgenograms reveal the lunate dislocated volarward and rotated 90 degrees. Immediate reduction under general anesthesia or brachial block is required, and universally good results from early closed manipulative reduction are obtained. Cases in which reduction is done later frequently require excision of the lunate bone. This injury is mentioned principally to emphasize the need for prompt reduction under general anesthesia.

*Fractures of the Metacarpal Bones. Injuries of the First Metacarpal Bone*



*Figure 157.* Bennett fracture of the base of the thumb. (Eliason, E. L.: Am. J. Surg, *6* 501, 1929)

*(Thumb).* Bennett's fracture, which is in reality a fracture-dislocation at the base of the first metacarpal (Fig. 156), results from a blow directed upward through

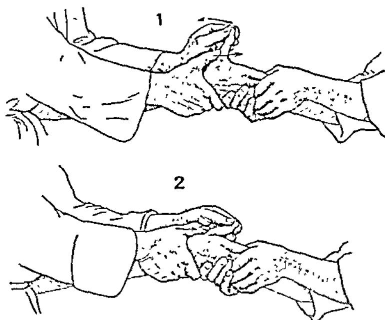



*Figure 158.* Reduction of a dislocation of the thumb. *1*, Extension of the thumb with downward pressure at the base. *2*, Continued pressure at the base of the thumb with flexion and traction. (Maisonnet, J.: Petit chirurgie. Paris, Gaston Doin et Cie.)

the longitudinal axis of the thumb or from a fall on the abducted thumb. The inner fragment remains in position whereas the shaft fragment is displaced proximally and laterally (Fig. 157). Accurate reduction is essential in this fracture because of the articular involvement. In early cases fractures can readily be reduced under procaine hydrochloride anesthesia by traction on the thumb with direct pressure on the radial side of the base of the thumb forcing it inward, and the position can generally be maintained by wide abduction of the thumb (Fig. 158). If displacement recurs in spite of the abducted position, continuous traction should be applied with the thumb abducted and extended by the use of a pin through the pulp of the thumb or through the phalanx. Traction and splint should be maintained for four weeks and then should be replaced by a similar splint (Fig. 159) which holds the thumb extended and moderately abducted but without traction for two weeks longer.



*Figure 159.* Spica plaster cast for Bennett fracture. (Eliason, E. L.: Am. J. Surg., 6:501, 1929.)

Fractures of the shaft of the first metacarpal without appreciable displacement, or those in which the fracture can be accurately aligned and reduction easily maintained, are adequately immobilized with a plaster cast extended from the proximal portion of the forearm under the abducted and apposed thumb. Unstable fractures of the shaft will require continuous traction, as described for Bennett fractures.

*Fractures of second to fifth metacarpal bones* result from a blow directed upward through the knuckles or against the dorsum of the hand, or from crushing injuries. They cause pain, swelling, crepitus, prominence of the metacarpal head in the palm or shortening of the shaft. Roentgenograms should always be made when such symptoms are present

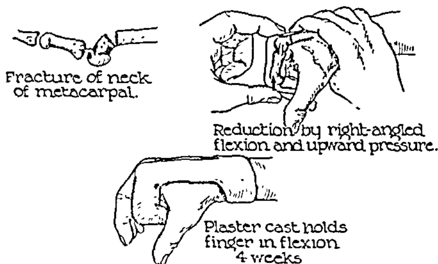



*Figure 160.* This simple fracture is too often badly managed. Malunion leaves the hand crippled because of inability to grasp firmly due to displacement of the head of the metacarpal bone into the palm. (Compere, E. L., and Banks, S. W.: Pictorial Handbook of Fracture Treatment. Chicago, Year Book Publishers, Inc.)

after injury. Transverse fractures of the shaft are treated by correction of the alignment after infiltration with procaine hydrochloride and application of molded plaster splints to the dorsal and palmar surfaces from the middle of the forearm to the proximal interphalangeal joints. It is important that the palmar splint be molded carefully, and the proximal phalanges should be flexed 45 degrees on the metacarpals. A roller bandage may be placed in the palm of the hand in lieu of a plaster splint and the involved digit immobilized with adhesive tape or bandage, leaving the adjacent uninjured digits free. Spiral and oblique fractures may require continuous skeletal traction to prevent redisplacement; four weeks of immobilization is sufficient time for functional solid union. It is important to immobilize only the involved metacarpal if possible and allow free movement of the other digits of the hand in order to prevent stiffness and prolonged disability.

*Fractures of Neck of Metacarpal.* These fractures allow displacement of the distal end of the metacarpal into the palm of the hand and are fairly common. Accurate reduction is essential to prevent the depressed head from forming a prominence in the palm if union progresses in malposition. The depressed head of the metacarpal, which can be felt in the palm, should be forced dorsally by direct pressure by the operator's thumb and held while the proximal phalanx is flexed 90 degrees so that the shaft of the bone falls directly under the metacarpal head (Fig. 160). The fingers should then be splinted in position with the molded plaster splint in the manner suggested by Watson-Jones.[2] Plaster should extend from the dorsum of the forearm at its middle third along the back of the hand across the knuckles, with the narrow portion extending down over the flexed finger. It should be carefully molded in this position with the dorsal thrust on the finger while the plaster is setting. The splint may be continued without change for three or four weeks with active exercise of the uninvolved digits. If accurate reduction of metacarpal fractures, particularly of the index finger or of the neck, cannot be obtained by closed procedures, one should not hesitate to recommend open reduction, as malposition frequently results in considerable permanent disability and impaired function of the hand.

*Dislocations of the Fingers. Dislocation of the metacarpophalangeal joint,* particularly of the thumb, is fairly common and reduction may be difficult at times. As the phalanx dislocates dorsally, the head of the metacarpal is forced through a narrow slit in the capsule. This forms a tight band about the neck of the metacarpal which makes reduction

impossible except by open reduction. Occasionally, the flexor tendon is also twisted about the neck of the metacarpal and the base of the phalanx in such a way that it cannot be disengaged by manipulation (Fig. 156). Reduction by manipulation should always be attempted. This can be accomplished under local anesthesia by hyperextending the finger without traction until it forms less than a right angle with the shaft of the metacarpal. The base of the phalanx is then pushed distally by the operator's thumb until it has been pushed through the slit in the capsule and is passed over the head of the metacarpal. Traction may then be made on the phalanx as it is flexed; at the same time the operator's finger, which rests against the base of the phalanx, should follow through, forcing it into normal relationship with the head of the metacarpal (Fig. 158). Roentgenograms should be made to be certain that reduction is complete. After reduction a splint should be applied to the finger in moderate flexion as in cases of other phalangeal fractures. Splinting should be continued for three weeks.

*Interphalangeal dislocations* easily result from forceful hyperextension and may be reduced spontaneously. If the dislocation persists, it may be reduced after infiltration of procaine hydrochloride in the base of the finger by hyperextending the phalanx, forcing its base distally and making traction on the phalanx as it is being flexed. A splint is then applied to the finger and moderate flexion will maintain the reduction. A light comfortable splint may be made of several layers of narrow bandage over which collodion is applied several times. Simple dislocations are generally immobilized for three weeks.

*Fractures of the Phalanges* (Fig. 161). *Fractures of the middle and proximal phalanges* represent almost half the fractures in the region of the hand. The break usually occurs in the proximal part of the phalanx because the pull of the lumbricales and interossei muscles, which normally flex the proximal and extend the distal fragments, causes forward angulation at the site of the fracture. For this reason splinting should never be applied with the finger in complete extension, but the proximal interphalangeal joint should be flexed as far as possible and the metacarpophalangeal joint flexed 45 degrees. Traction in addition to flexion is usually essential, especially in oblique fractures. When splints

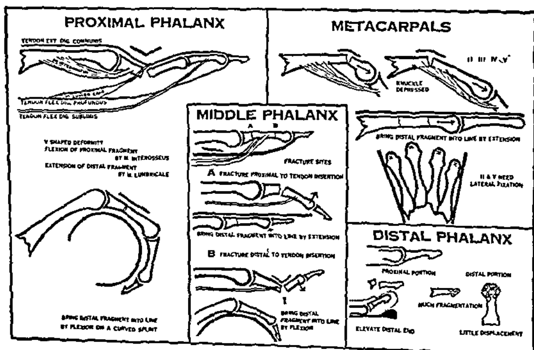
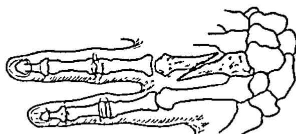



*Figure 161.* Illustrating mechanisms of deformities produced by the action of the intrinsic muscles and tendons with suggestions of means for overcoming these deformities. (McNealy, R. W., and Lichtenstein, M. E.: Surg., Gynec. & Obst., *55*:758, 1932.)



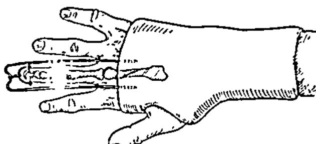




*Figure 162.* Accurate reduction and immobilization of oblique or comminuted fractures of a metacarpal bone require traction. (Compere, E. L., and Banks, S W.: Pictorial Handbook of Fracture Treatment. Chicago, Year Book Publishers, Inc.)

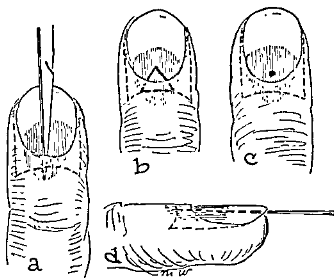



*Figure 163.* Methods of decompression of a subungual hematoma; *a*, A sharp-pointed scalpel lifts the eponychium away from the base of the nail *b*, A V-shaped piece is excised from the base of the nail *c*, A small hole is drilled through the nail. *d*, A needle is inserted under the nail from the distal end.

are applied to any of the fingers, the ends of the flexed splints should always be directed toward the thumb side of the wrist to prevent rotational displacement. Continuous traction (Fig. 162), recommended by Watson-Jones and Boehler, with a traction pin through the pulp or distal phalanx is probably the most satisfactory method of treatment. Rubber bands can be used to exert mild continuous traction and a wire splint can readily be fashioned from a wire coat hanger, which is usually available. The deformity in fractures of the middle phalanx depends on which side of the insertion of the flexor sublimis tendon the break occurs, and the displacement may be angulated forward or backward. If the fracture is distal to its attachment to the phalanx, the proximal fragment will be

flexed with volar angulation of the finger, and reduction is accomplished by flexion of the digit. If the fracture is proximal to the sublimis insertion, the deformity should be corrected by extension of the digit and application of a straight dorsal splint.

*Fractures of distal phalanges* are the most common result of crushing injuries. These fractures are frequently comminuted but are seldom appreciably displaced. Blood, which may accumulate underneath the fingernail under considerable tension, causes considerable pain which may be relieved by drilling a hole in the fingernail to permit the blood to escape (Fig. 163). The fracture may be treated by protecting the end of the finger for ten to fourteen days on a wooden or metal splint. When the tip of the finger is avulsed, primary application of full thickness skin graft can frequently save considerable length of the digit; in compound fractures in all cases every effort should be made to save the finger tip.

*Mallet Finger (Baseball Finger).* Avulsion of a small portion of the bone from the dorsal margin of the proximal end of the distal phalanx to which the extensor tendon is attached occurs when a ball strikes the end of the finger; hence, the name "baseball finger" or "drop finger." Reduction is accomplished by keeping the distal interphalangeal joint hyperextended so that the phalanx is in contact with the avulsed fragment. Treatment should be instituted promptly to ensure a satisfactory result. Hyperextension on an aluminum splint is not as satisfactory as the molded plaster splint, described by Watson-Jones, which consists of a circular plastered dressing with flexion at the proximal interphalangeal joint (Fig. 164). Hyperextension of the distal phalanx is accomplished by molding the plaster while it is setting. The hyperextended position should be maintained at least six weeks. This type of dressing does not interfere with active use of the rest of the hand.

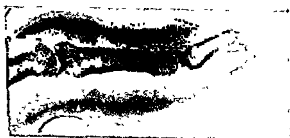


*Figure 164.* Position for immobilization of "baseball finger" in plaster. (Saypol, G. M., and Slattery, L. R.: Surg., Gynec. & Obst., *79*:522, 1944.)

### Other Injuries and Diseases of the Upper Extremity

***The Shoulder.*** The shoulder is somewhat more vulnerable to sprain because of the insecurity of the head of the humerus within the shallow glenoid. After injury to the shoulder, possible dislocation should be considered. If the hand can be placed on the opposite shoulder, and the elbow approximated to the thoracic wall, and there is no depression beneath the acromion process, dislocation can be satisfactorily excluded clinically but roentgenograms should be made if there is any uncertainty. Temporary use of a sling, local radiant heat and early active exercises are important in the treatment of strains and severe contusions, particularly in elderly people, to prevent periarticular adhesions and subsequent "frozen shoulder."

*Bursitis about the Shoulder.* Subdeltoid bursitis, a common condition causing pain in the shoulder, seems to have little relationship to trauma. The onset is sudden with severe pain and exquisite localized tenderness in the anterior aspect of the shoulder. Pain may be referred to the region of the deltoid insertion and sometimes into the hand. Abduction and external rotation of the shoulder are greatly restricted by pain. Roentgenograms should be taken in internal and external rotation and may reveal a plaque of calcium near the greater tuberosity in either the bursa or the tendinous cuff. This condition, either with or without calcified deposits, may sometimes be relieved by injections of procaine hydrochloride (Fig. 165). However, success of this treatment depends upon accurate introduction of the needle into the tendinous foci so as to puncture

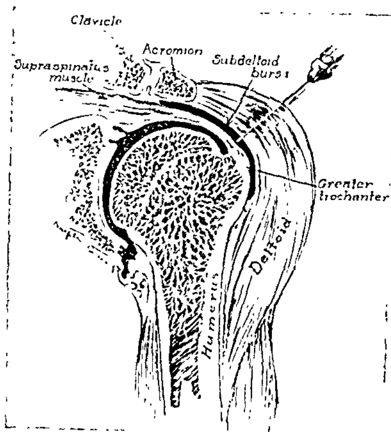



*Figure 165* Frontal section of the shoulder region, to show the point of insertion of the needle for the purpose of anesthetizing the subdeltoid bursa as a diagnostic and therapeutic procedure (Haldeman, K. O, and Soto-Hall, R.: J A M.A , *101*.2319, 1933)

the membrane, relieving the tension and dissipating the calcified deposits. If the surgeon succeeds in penetrating the focus and rupturing the retaining membrane by the injection, the associated pain is usually relieved. Often, however, he fails and the patient then is more miserable than before. In such cases, several other treatments may be tried. Roentgenotherapy combined with adequate sedation with opiates and use of a sling often provides relief in a few days. Daily administration of 800 mg. of phenylbutazone (tablets), taken in divided amounts after meals, has given prompt relief in many cases. However, in acute recurrent cases with calcified deposits we believe it advisable to operate, expose the focus, incise the tendon and remove the calcified deposits with a curet and by lavage. After subsidence of the acute pain, rapid restoration of motion of the shoulder (Fig. 166) is imperative to prevent "frozen shoulder," which frequently results in patients who are afraid to exercise the shoulder.

*Adhesive capsulitis (peritendinitis, frozen shoulder)* is the result of immobilization of the shoulder, usually due to subdeltoid bursitis or heart disease. Prolonged use of slings in old people with fractures of the wrist or forearm is also a contributory etiologic factor. This entity is characterized by considerable limitation of abduction and internal and external rotation of the shoulder. Pain is felt frequently at night and disturbs sleep. Patients cannot rest on the involved side, and radicular pain is present about the deltoid insertion. At times the patient complains of associated pain on the lateral aspect of the cervical muscles and even in the forearm and hand. Treatment consists in patient and persistent stretching of adhesions by vigorous voluntary exercise taken at frequent intervals each day. In addition, at least once each day hot applications or diathermy should be administered to the shoulder muscles followed by massage. Several weeks of such intensive treatment is necessary in order to regain even a portion of the lost motion, and freedom from pain and complete range of motion

are seldom realized before several more months.

Suprascapular nerve block with procaine hydrochloride or dolamine is a simple procedure, safely performed in the office, which does much to relieve the shoulder pain so that the patient can get started on the exercise program. Duncan[3] described the technique of suprascapular nerve block as follows: ". . . the inferior angle of the scapula is identified and marked on the skin as are the medial and lateral ends of the spine of the scapula. A line is projected from the inferior angle of the scapula through the midpoint of the line of the scapular spinous process. The upper outer angle made by these two lines is then bisected and under sterile precautions a skin wheal is raised 1.5 cm. outward with a 2 per cent solution of procaine hydrochloride. A 22 gauge needle is pushed downward and medially until it strikes the scapula, when it is withdrawn and redirected slightly upward and inward 1 cm. further until it hits the suprascapular notch. Paresthesias are usually noted in the shoulder or arm at this stage. The plunger is withdrawn to be certain blood has not been aspirated; then 8 to 10 cc. of the procaine solution is deposited. Preferably, 3 cc. is deposited followed by 10 cc. of dolamine, as this gives a much more prolonged action."

Small doses of ACTH (corticotropin) and cortisone are useful adjuncts early in the treatment program. Coventry[4] advocated daily intramuscular injection of 100 mg. of cortisone acetate for five days. If no improvement is noted, cortisone is discontinued. If improvement is obtained, 50 mg. daily is injected for five more days. We have abandoned forceful manipulation under general anesthesia, as the trauma of manipulation prevents the patient from adequately doing active exercises and only in rare cases is it beneficial. Occasionally, the neck of the humerus has been fractured by a vigorous operator.

*Ruptures of Tendons. Rupture of the supraspinatus tendon* occurs most frequently in laborers more than 45 years of age. After a severe strain on the shoulder or a heavy fall an acute pain and snap are felt in the shoulder, followed by inability to abduct the arm. The older the patient the less trauma is necessary to produce such an injury, as there may be advanced degenerative changes in the tendon. Examination on attempted abduction is accompanied by

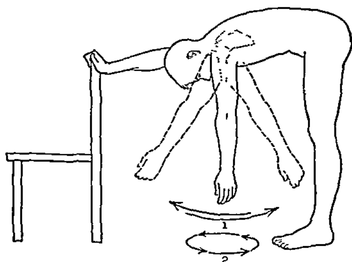



*Figure 166* Stooping exercises for shoulder lesions (after Codman) The patient bends forward, grasping a chair with the hand of the sound arm; the painful arm falls forward of its own weight to become perpendicular to the floor. In this position, the patient is asked to swing the arm forward and backward gently, raising it as far as possible up beside the head. In addition, circular motions should be performed, carrying the arm in an arc forward and backward. It is often advisable to have the patient hold something in his hand during this exercise. The old-fashioned flat-iron is a good substitute for a dumb-bell for this purpose. (Ferguson, L. K.: Surgery of the Ambulatory Patient. Philadelphia, J. B. Lippincott Co.)

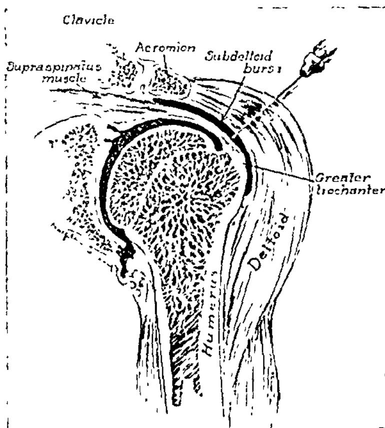



*Figure 165* Frontal section of the shoulder region, to show the point of insertion of the needle for the purpose of anesthetizing the subdeltoid bursa as a diagnostic and therapeutic procedure (Haldeman, K. O., and Soto-Hall, R.: J.A.M.A., *101*:2319, 1935.)

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posure of the ruptured muscle or tendon and either suture of the long head to the short head or repair of the muscular junction as indicated. An exceptional elderly patient who retains enough strength for all but the most arduous occupations can be treated by heat and massage.

*The Elbow. Radiohumeral bursitis (tennis elbow, epicondylitis humeri) is* frequently encountered in the manual laborer or the patient engaged in strenuous golfing or tennis—activities that require excessive supination and pronation. The patient complains of pain about the outer aspect of the elbow, weakness of the forearm, pain on shaking hands and on grasping objects. Acute tenderness is confined to an area over the lateral epicondyle of the humerus. Forced extension of the fingers against resistance will cause severe pain on the extensor surface of the forearm. Roentgenograms should be made to rule out other diseases or injuries, and occasionally reveal calcification of the radiohumeral bursa.

Many types of treatment have been advocated. Dorsal flexion of the fingers and wrist in the relaxed position on a plaster splint that extends from the elbow to the finger tips is helpful. If a calcified deposit is present in the radiohumeral bursa, roentgen-ray therapy is usually effective. Injections of procaine or, more recently, of hydrocortisone often give relief. Manipulation of the elbow with stretching of the lateral ligament of the joint is popular in England. Avoidance of the activity that brought about the condition is most important. Persistent chronic cases may require excision of the radiohumeral bursa or release of the aponeurosis.

*Olecranon Bursitis (Miner's Elbow).* Swelling and tenderness over the tip of the olecranon are caused by inflammation of the bursa which is situated between the skin and the olecranon process. Traumatization of this area by persistent pressure produces inflammation and distention of this bursa with fluid. Acute cases may be treated by aspiration of the bursa and application of a posterior splint to immobilize the elbow for three or four days. If the condition becomes chronic, excision of the bursa is necessary to effect a cure.

*The Hand. Traumatic Osteitis of the Semilunar Bone (Kienböck's Disease).* This condition, described by Kienböck, is generally accepted to be traumatic in origin although it may occur without definite trauma as the result of occupational conditions, such as overuse from painting or use of a pneumatic hammer. The osteitis may develop several months after the original injury. Symptoms are similar but less severe than those of a recent semilunar fracture. The grip is weak, the wrist is somewhat swollen and there is a dull ache increased by activity, with local tenderness on pressure over the involved carpal bone. The diagnosis is confirmed by roentgenography. Roentgenograms show condensation of the lunate bone. Conservative treatment consists in immobilization similar to that employed for fractures of the scaphoid for a period of eight weeks, and protection by use of a molded reinforced leather wristlet for eight more weeks. Occasionally, if this is not effective, excision of the involved carpal bone or, in severe cases, arthrodesis of the wrist is necessary.

*Tenosynovitis.* Inflammation of the tendon sheaths about the wrist occasionally occurs and usually is the result of strenuous, oft-repeated or unaccustomed use of the wrist or hand. Serous or fibrinous fluid may accumulate in the affected tendon sheath, sometimes resulting later in chronic sclerosing changes and stenosis. Tendons most frequently involved are the abductor pollicis longus and the flexor tendons of the fingers. Constricting tenosynovitis of the abductor pollicis longus and the extensor pollicis brevis is termed de Quervain's disease. Acute pain and tenderness are located directly over the radial styloid process. Forced abduction or flexion of the thumb causes severe pain in the region of the radial styloid and is diagnostic of this condition. Conservative treatment consists in immobilization of the wrist and thumb in a relaxed position by use of an alumi-



*Figure 167.* The function of the supraspinatus is to fix the head of the humerus while the deltoid abducts the arm. If the tendon is ruptured or avulsed, weak abduction to 60° by capular movement is all that is possible. (Watson-Jones, R: Fractures and Other Bone and Joint Injuries, ed. 2)

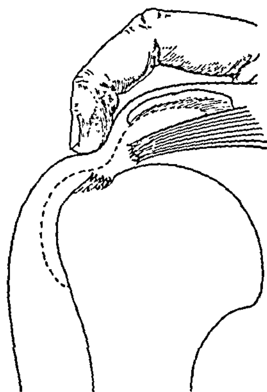


*Figure 168.* "Tip of finger pressing on eminence and on sulcus. The plane of this diagram is halfway between the coronal and sagittal . . . It is the ability to put the finger in this position which enables one to make the clinical diagnosis of rupture of the supraspinatus tendon. The dotted line represents the contour of the bursa. The sulcus lies immediately upon the tip of the finger and the eminence just external to it. Therefore, . . . the tender point in a case of rupture is represented by a depression, but in cases of calcified deposit, by an eminence at the corresponding position" (Codman, E. A.: Am. J. Surg., 42: 603, 1938, reproduced from Codman, E. A.: The Shoulder, Rupture of the Supraspinatus Tendon, and Other Lesions. Privately printed by E. A. Codman, 227 Beacon St., Boston, Mass., Thomas Todd Co.)

considerable pain and the use of a shrugging mechanism (Figs. 167 and 168). If the weight of the arm is taken by the examiner, it can usually be elevated to a horizontal plane. The patient may be able to hold his arm voluntarily in this position, but the slightest pressure in a downward direction by the examiner increases the pain and the arm falls down to the side. This is particularly true of complete ruptures. If the examiner is in doubt, infiltration at the point of maximal tenderness with 10 cc. of 1 per cent solution of procaine is recommended to relieve the pain so that the power of attaining and maintaining abduction may be tested. With partial tears the power of abduction is maintained when pain is relieved. With complete tears it is not. Treatment of complete ruptures is surgical. If rupture is incomplete, the patient should wear an abduction splint for three to six weeks.

*Rupture of the long head of the biceps* may occur through the tendon of the long head at the level of the glenoid cavity or may take place at the musculotendinous junction. It occurs most frequently in patients over 45 years of age and is probably preceded by degenerative changes in the tendon or muscle. According to Gilcreest,[5] rupture of the biceps is third in frequency of occurrence of muscular ruptures, the Achilles tendon and extensor quadriceps being first and second, respectively. Clinical manifestations include pain and disability about the arm, with swelling of varying degree depending on the severity of the rupture. Palpation of a definite dehiscence makes the diagnosis positive, and flexion of the pronated forearm is more forceful than when the arm is in supination. This is a helpful sign of biceps rupture. Treatment of acute cases is a major surgical procedure consisting of immediate ex-

lower back. It is characterized by development of pain, soreness and stiffness in the muscles of the back several hours after prolonged or vigorous stooping and lifting efforts. All movements of the lower back produce sharp twinges of pain that limit bending. There is generalized tenderness over the paravertebral muscles. Stiffness and soreness are greatest after rest and gradually improve with moderate activity. Still more relief is obtained by application of heat and massage and administration of 10 grains of aspirin every four hours. The condition is usually relieved after two to four days if not aggravated by further lifting efforts.

### Sprains of the Lumbosacral Joints

*Sprain* is a term applicable to wrenching of a joint that produces a stretching or laceration of the supporting ligaments. It can be used to describe such injuries occurring at the lumbosacral junction, but it should be recognized that the lumbosacral articulation is composed of the intervertebral disk and the two zygapophyseal joints formed by the articular facets of the fifth lumbar and first sacral vertebrae, the supporting ligaments that protect the intervertebral disk, the capsules covering the zygapophyseal joints and the interspinous, supraspinous, intertransverse and iliolumbar ligaments that support all three joints. Therefore, a wrenching force applied to the lumbosacral articulation may overstretch or tear one or more of these ligaments, produce changes in the intervertebral disk and traumatic arthritis of the zygapophyseal joints.

*History*. The mechanism of injury is often clearly described by the patient. Usually, he will relate that while lifting or carrying a heavy weight something occurred which produced a sudden jerk or wrench. A typical example is one in which two workmen are carrying a heavy beam; one suddenly drops his end and the other, who is still holding his, receives a sudden jerk which causes immediate, severe, sickening pain in the lower part of his back. He may become faint and fall, and may have to be taken to a hospital on a stretcher. In other instances, however, after resting for a while, the patient may be able to stand and walk and even carry on with light work for several hours. However, after some rest, the low back pain increases, he usually rests poorly during the night and is unable to get up for work the following morning because of pain and stiffness in the lower back.

*Examination*. During the first days after such an injury the patient finds it difficult or impossible to get out of bed. Twisting or turning in bed produces acute spasms of back pain. The paravertebral muscles are taut and the lumbar curve is flattened. Tenderness may be generalized or sharply localized to both lumbosacral angles. After a few days, the patient may stand and walk with difficulty because the lumbar muscles continue to be in spasm; bending movements are limited and tenderness persists in the lumbosacral angles.

Roentgenograms made in the anteroposterior, lateral and oblique planes fail to demonstrate a fracture or dislocation. However, they may reveal one or more of

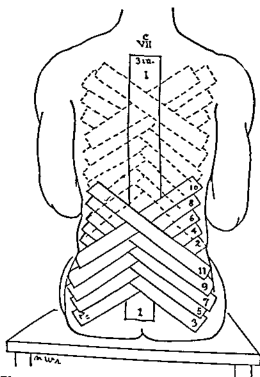



*Figure 169*. Method of applying adhesive straps for a strain of the back. The patient sits in increased lordosis while the adhesive tape is applied. It is often convenient to have him lie prone with the chest and hips elevated.

num or plaster splint. In chronic cases splinting is seldom effective and release of the constriction by longitudinal incision of the tendon sheath generally gives prompt and permanent relief.

*Snapping Finger or Trigger Finger.* Stenosis of the flexor tendon sheath causes a syndrome known as snapping finger or trigger finger. A small, nodular, tender mass can be palpated in the palmar aspect of the hand directly over a metacarpal head. The finger can be flexed voluntarily into the palm but is difficult to extend and forcible extension causes a snapping sound. The constriction of the tendon sheath always occurs over the anterior surface of the metacarpal head. Splinting that prevents motion of the finger will relieve about one-half of the patients with this condition. Those who are not relieved within three weeks should have the tendon sheath incised.

*Ganglion.* A ganglion is a small, smooth, cystic structure which contains thick, clear mucinous fluid and connects with a tendon sheath or the articular capsule of a joint by a narrow pedicle. It may have a single cavity or may be multilocular. The most common site for ganglions is the dorsum of the wrist but they occasionally appear over the ankle and other joints. They usually appear spontaneously and may cause but little discomfort except after overuse or strain of the wrist.

The time-honored treatment of rupturing the ganglion by a blow with a book is painful and often followed by a recurrence. Some have disappeared after being injected with hydrocortisone. The most satisfactory treatment is surgical and the operation is often more extensive than is anticipated. The after-treatment following rupture or excision consists of application of a splint to maintain dorsiflexion for three weeks, followed by use of a soft leather wrist corset for several weeks longer.

*Rupture of the Extensor Pollicis Longus Tendon.* Spontaneous rupture of this tendon may follow occupational trauma, as in kettle drummers, or may follow a fracture of the lower end of the radius. Since rupture of the tendon is preceded by chronic degenerative changes, it can occur with but little pain. Diagnostic signs are inability to extend the distal phalanx of the thumb against resistance, and absence of the subcutaneous bowstring that appears at the radial side of the wrist when the thumb is actively extended. Treatment always requires an operation for suture of the tendon and, in some cases, use of a tendon graft may be indicated.

*Severed Tendons.* When an incised or lacerated wound is found to lie over the course of a tendon the examiner should carefully test the voluntary movements of the parts controlled by the muscles and tendons in the vicinity of the wound. If one or more tendons are thus found to be severed in a wound made by a knife or a piece of glass and the time elapsed after injury does not exceed twelve hours, immediate tendon suture should be performed if possible. However, if the wound is extensive, macerated and dirty, it should be carefully cleansed and débrided to prevent infection. This is an essential first step in treatment and it may be necessary to defer repair of the tendon until sound healing has occurred.

In either case definitive treatment of severed tendons should not be undertaken in an office or emergency room. In cases with clean cuts, the skin may be sutured and the part splinted as a first aid measure, but those with severe lacerated wounds should only have a large sterile dressing applied and be referred as promptly as possible to a good surgeon and hospital for further care.

## THE LUMBAR SPINE

### Muscle Strains

A strain may be defined as a condition produced in a part by overuse or excessive stretching. It is properly applicable to injuries of the lumbar and dorsal muscles caused by efforts made in heavy lifting or prolonged, repetitive lifting of lighter weights. The injury is limited to the muscles and does not involve the ligaments or joints in the

or a narrowed disk are present that they should not be regarded as contributing to or prolonging disability. However, severe degenerative disk changes, such as extreme narrowing of the intervertebral disk with partial or complete bridging of the intervertebral space by hypertrophic spurs, indicate the pre-existence of a disorganized joint which might easily be aggravated by wrenching and therefore requires a longer period of convalescence.

### Malingering Associated with Low Back Injuries

The tendency for many patients to exaggerate or prolong their complaints in an effort to establish a compensable disability is generally recognized. Others may unconsciously exaggerate their symptoms in order to gain sympathy or to avoid unpleasant duties or obligations. Some probably actually have justifiable minor complaints and slight partial disability which they grossly overrate, hoping to obtain greater remuneration. Continuance of treatment in such cases is destined to failure and the effort frequently serves only to convince the patient that he does have some obscure condition that confounds his physician, and he then becomes a confirmed chronic mental cripple. It therefore behooves the physician to exercise utmost care in taking the history and performing the examination, first to maintain a completely objective point of view and second not to overlook any pertinent physical signs and symptoms. He then must determine definitely whether, in his own judgment, the patient has or has not actually recovered from the physical injury received at the time of the accident. If he decides that the patient is still physically disabled because of a persisting lesion which is the direct result of the accident, he then must cite the *objective physical signs* and consistent subjective findings which justify his opinion, the treatment indicated, the probable length of time required for maximum recovery and the extent of residual permanent disability, if any, that might be anticipated. On the other hand, if after a detailed, unbiased survey of the condition, the physician is convinced that the patient's complaints are exaggerated or purposely misrepresented and there are no frank, objective physical signs and consistent subjective symptoms to support the patient's claims, he then should make an unequivocal statement to this effect to all concerned, and tell the patient he has fully recovered, is ready to resume active duty, and requires no further treatment.

A psychoneurotic patient or a malingerer will usually describe in great detail the way in which his injury occurred, the excessive pain he suffered, and many vague, bizarre complaints that cannot be related to the injury. He is prone to dwell upon neglect by his employers or the insurance company and to be critical of all previous treatment. He is full of self-pity and his outlook for recovery is gloomy.

On examination, a malingerer will demonstrate many findings totally inconsistent with a diagnosis of chronic low back sprain, and exaggerated responses to all tests designed to elicit painful motion or tenderness.

The diagnosis of malingering (purposeful misrepresentation of symptoms and signs) or of psychoneurosis (conscientious conviction of the persistence of disabling symptoms) rests essentially upon numerous exaggerations and inconsistencies in the history and examination together with the absence of any objective physical signs in the course of a thorough examination.

### Crushed Fractures of the Lower Dorsal and Lumbar Vertebrae

Crushed fractures and fracture dislocations are generally caused by forcible forward bending of the trunk by a weight from above. This produces a sudden jack-knifing or knuckling of the spine, usually in the upper lumbar or lower dorsal region, with narrowing and compression of the body of one or more vertebrae. When the force is great, the body of the vertebra may be severely crushed and the spine acutely angulated or even dislocated to a degree that will

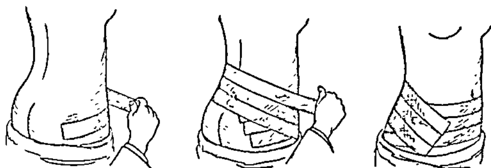


*Figure 170* Krida method of back strapping. (Krida, A.: Am. J. Surg, *6* 130, 1929)

the congenital anomalies frequently observed in this region, namely, spondylolysis or spondylolisthesis, a sacralized transverse process, a transitional sacral vertebra or occult spina bifida. They may also demonstrate a narrowed intervertebral disk or hypertrophic changes at the margins of the vertebral bodies. Any or all such anomalies or changes must have existed prior to injury and cannot be regarded as a primary cause of disability.

*Treatment.* The lesions to be treated are sprain of the lumbosacral zygapophyseal joints, overstretching and partial rupture of the supporting ligaments and traumatic arthritis of the articulations. Therefore, the indications for treatment are the same as for a sprained ankle or knee, namely, relief of muscle spasm by procaine injections and sedation, rest and support for the affected joint, relief from weight bearing and motion during the acute phase followed by application of heat and massage and graduated activity with suitable support for the back during the convalescent stage (Figs. 169 and 170).

Complete bed rest on a firm mattress and springs is the first essential. Codeine or morphine should be given in doses sufficient to relieve pain and permit sleep during the first 48 to 72 hours. From 3 to 5 cc. of a 1 per cent solution of procaine hydrochloride should be injected into the muscles at the various points of maximum tenderness, with repetition of injections daily for several days if necessary. A heating pad or hot water bottle placed under the hollow of the back for 30 to 60 minutes every three or four hours adds to the patient's comfort. Pillows placed under the knees also relax the lumbar muscles and relieve pain.

Two to four weeks of bed rest are required in severe cases before the patient can turn freely and sit up without producing pain and muscle spasm in the back. Moreover, experience has shown that this amount of time is required for the quiescence of traumatic arthritis and repair of injured ligaments. The patient then may be fitted with a lumbosacral corset (not a sacro-iliac belt) and permitted to sit up and walk about for increasing lengths of time but should lie flat in bed several hours each day. During his ambulatory periods he should have physical therapy consisting of application of heat and massage to the lumbar muscles followed by gentle, active and passive movements of the back and hips while in the prone position. After a week or more of such treatments, he may be permitted to be up more of the time and begin active bending exercises in the standing position. Four to six weeks after injury most patients can discard the support and begin light work. Throughout treatment the patient should be assured that he has not seriously injured his back and that he may confidently expect to resume his former activities within two to three months.

The presence of lumbosacral anomalies, a narrowed intervertebral disk or minor hypertrophic spurs, which are frequently noted in the roentgenograms of patients over 40 years of age, may be considered as *possible predisposing causes* for injury, but should not be given special consideration in connection with treatment or prognosis. The anomalies have existed since birth and have withstood hard usage and, often, previous injuries without resultant disability. Prompt and complete recovery is likewise so frequently obser

dosis is usually present. Bending movements are generally free and complete, but some pain is felt at the extremes of forward and backward bending. Muscular spasm is absent. Tenderness is elicited at various points, particularly the lumbosacral angle on each side and over the sacro-iliac joints and posterior iliac spinous processes. Roentgenographic examination usually yields negative results except for occasional lumbosacral anomalies which seldom have any relation to the symptoms.

*Treatment.* Objectives of treatment are to relieve the chronic soreness and stiffness in the lumbar muscles and to prevent recurrence by correction of the postural defects or change of occupation. Relief of the soreness and stiffness is best obtained by complete bed rest for a few days during which the patient receives applications of heat and massage over the lower dorsal muscles. A graded regimen of postural exercises, combined with a reducing diet for those who are overweight, should then be instituted. Those with relaxed abdominal muscles and poor posture should wear a corset until their muscles have been restored and their postures corrected by appropriate exercises. In addition, those whose work is obviously related to the backache should change their occupation, if possible, or at least should arrange certain adaptations that will provide rest and change of position.

### *Psychogenic Back Pain*

In many victims of anxiety, tension or frustration, fixations develop upon the lower part of the back and the patient complains of severe, often disabling pain. In such cases the history varies greatly. Complaints are never definitely localized, pains have queer radiations, nothing seems to give appreciable relief and the patients offer many theories of their own as possible explanations. Despite their professions of agonizing pain and disability they are usually able to engage in most activities that interest them.

*Examination.* Many of these patients have postural defects or lumbosacral lesions which might reasonably account for mild or moderate pain, but even after these have been adequately treated the patient claims no relief. Therefore it is obvious that unless they can obtain some insight into the psychiatric problems, permanent relief is not likely to be obtained. However, all such patients deserve thorough study because they, too, can have tumors, arthritis, tuberculosis and other truly disabling skeletal lesions which may be completely obscured if one is too much impressed by the obvious psychogenic factor.

*Treatment.* If no definite cause for low back pain can be found, the patient should be so informed and strongly advised to seek psychiatric help. If reasonable cause for slight or moderate back pain is found, appropriate treatments should be given, but at the same time the patient should be informed that the major problem is an emotional disturbance, and that unless this can be corrected complete relief will not be obtained.

### *Low Back Pain Due to Intervertebral Disk Lesions*

Progressive degenerative changes of the fourth and fifth lumbar disks are responsible for many complaints referable to the lower back. Etiology of the degenerative process is not definitely known. However, it seems logical to assume that wear and tear or repeated minor injuries initiate such changes, since the two disks usually involved are subject to all of the weight of the trunk above and also possess a greater range of motion than other joints of the lumbar and dorsal spine. Earliest changes noted are softening of the nucleus pulposus and the fibrocartilage (annulus fibrosus) in the posterior portion of the disk. Under pressure from the superimposed trunk weight, aggravated by the pinching resulting from muscle contraction and motion in these joints, the softened annulus tears or thins out, permitting the nucleus to bulge or protrude against the posterior longitudinal ligament. This ligament, not being strong enough to resist the protruding nucleus, bulges at its weaker points posterolater-

pinch or crush the spinal cord, thus producing immediate paralysis of greater or lesser extent. Paralytic ileus or a retroperitoneal hematoma often develops rapidly and may mask the signs and symptoms of a fractured vertebra. However, when the crushing injury is slight, the immediate pain and disability may be slight enough to cause the patient and the physician to assume that the injury was no more than a sprain. Roentgenograms should be made as soon as possible after injury. If they were omitted and the patient continues to have localized pain on bending after a few days, roentgenograms should then be made.

*Treatment.* If at the site of the accident the patient has severe back pain and is completely disabled or paralyzed, he should be carefully rolled onto a stretcher or wide board, lying with face down while being transported to a hospital for treatment. Correction of compressed fractures of the lumbar vertebrae can usually be accomplished by hyperextension and the corrected position can be maintained in a plaster jacket or suitable brace for six to eight weeks until bony union is established. However, before hyperextension is applied one should rule out fracture dislocation or fracture of the pedicle, which might cause displacement and spinal cord injury.

### Low Back Pain Unrelated to Injury

Many patients who have had no related injury complain of acute or chronic low back pain. A few such patients may have visceral lesions that produce pain referred to the back, such as prostatitis, pancreatitis or tumors involving the pelvic viscera, but most of them will have skeletal lesions accountable for the backache. Of these, some which must be considered, but which can be excluded by roentgenographic examination, are osteoarthritis, ankylosing spondylitis, Paget's disease, tuberculosis and osteomyelitis.

The more common causes of backache include postural and occupational strains, psychogenic back pain, and degenerative disk lesions (protrusion of the nucleus pulposus, rupture or prolapse of the intervertebral disk).

#### *Postural and Occupational Strains*

These are seen in adults, more frequently among women. The muscles of the lower back are subjected to overexertion and overstretching by reason of faulty body mechanics or by an occupation requiring long hours of work in a stooped or forward bent position. As a result of overuse the dorsal muscles become sore and ache, chiefly at their lower attachments to the lumbar vertebrae and pelvis.

*History.* The onset is gradual with fatigue and diffuse aching pain in the lower part of the back, which at first is usually noted after standing for some time or after sitting in one position for an hour or more and is relieved temporarily by change of position or by lying down. However, as time goes on, the aching pain becomes more severe and constant and is relieved only after lying down for some time. Often the patient then notes stiffness in the lower back on getting out of bed each morning, which improves after moving about for a while only to return as aching pain later in the day. Heat and massage or wearing a corset or brace generally provides temporary relief. Such patients are seldom totally disabled. They carry on with their daily routines but with more or less constant discomfort. In many instances the chronic muscular strain can be related to the patient's occupation, as for example, the secretary, bookkeeper or draftsman who sits for long hours in one position, leaning forward over his work, or the busy young mother attending and frequently lifting her babies or working over the wash tub, kitchen sink or ironing board.

*Examination.* Patients presenting such a history usually fall into two general postural groups, viz., the tall, slender, slightly stooped type with poor musculature, and the shorter, stocky obese type with relaxed pendulous abdomens. Poor posture and faulty weight-bearing lines are apparent in both. Exaggerated lor-

the long intervals of complete freedom of symptoms between attacks, gave rise to the former incorrect diagnosis of sacro-iliac displacement. These episodes of low back pain may be associated with intermittent twinges of pain in the buttocks and thigh, but such radiation is not constant.

*Examination* during an attack will reveal a man acutely disabled by pain referred to the lower back. Temperature, pulse and respiratory rate are normal. The slightest movements, such as turning in bed or raising the head, may aggravate the pain. If the patient is able to sit or stand, it will be seen that the lumbar curve is flattened and the paravertebral muscles are in tense spasm, usually more severe on one side and thus producing a trunk list toward the unaffected side. Active or passive movements involving the lower lumbar segments are inhibited by muscle spasm, and if forced, produce agonizing pain. Firm pressure over the spinous process of the fourth or fifth lumbar vertebra or in the lumbosacral angle on the affected side usually causes the patient to wince with pain.

Roentgenograms of the lumbosacral region, made in the anteroposterior, lateral, right, left and anterior oblique planes, usually reveal no significant changes. There may be such anomalies as spondylolysis, spondylolisthesis, a sacralized transverse process or spina bifida occulta, which may predispose or contribute to the symptoms but seldom are primary causes. Narrowing of an intervertebral disk (except when noted between a transitional first sacral vertebra and the body of the sacrum) is significant of degenerative disk disease. However, the protrusion of the nucleus frequently occurs at a different level from the visualized narrow disk; that is, the protrusion often occurs in a disk that appears radiologically normal.

Lumbar puncture and myelography, both of which are hospital procedures, are of doubtful value as positive aids in the diagnosis of disk lesions, particularly at the stage of protrusion. However, either or both are important if there is reason to suspect a tumor of the spinal cord.

*Variations of the Clinical Picture.* The onset of attacks is sometimes gradual rather than sudden. The pain may be only moderately severe and rather diffuse, with attacks lasting for several months. Nevertheless, they are usually periodic with varying intervals of freedom from symptoms. Occasionally, the onset of symptoms is the direct result of an injury or heavy lifting strain.

*Treatment.* Objectives of treatment are to relieve the affected joint from the weight of the trunk, relax the spasm of the lumbar muscles and immobilize the joint. These objectives are best accomplished by complete bed rest on a firm mattress (prohibiting sitting up or raising the head), adequate sedation and application of heat over the lumbar muscles. Administration of muscle relaxants, such as Tolserol, or injections of 1 per cent solution of procaine hydrochloride into the lumbar muscles seem to be beneficial in some cases. Bilateral leg traction serves to keep the patient on his back and perhaps hastens relaxation of the lumbar muscles. Fixation in a plaster spica extending from the axilla to the toes on the affected side is most effective when well applied but should seldom be continued for more than four to six weeks.

Complete bed rest or plaster fixation should be continued for some time after severe symptoms have subsided. Repair sufficient to prevent recurrences is dependent upon dehydration of the nuclear material together with fibrosis of the softened and torn annulus. These processes require weeks of time. After symptoms have been completely relieved by bed rest and additional time has been allowed for early repair, the patient may be allowed up with such splinting and protection of the back as will largely prevent bending movements. A plaster jacket or well-fitted corset reinforced with additional stays or steel uprights may thus be worn for four to six months longer.

Physical therapy measures of heat, massage and corrective exercises have little

ally, permitting compression of the nerve roots at their exits from the spinal canal through the intervertebral foramina. Protrusions are usually unilateral at the back of the fourth or fifth intervertebral disk and impinge upon the fifth lumbar or first sacral nerve root, thus producing pain that extends to the buttocks, posterior thigh, calf of the leg and foot.

Protrusion of the softened nucleus through the torn annulus and against the posterior longitudinal ligament is followed by desiccation and fragmentation of the nuclear material. The joint becomes somewhat relaxed and unstable so that further motion often produces a rupture of the posterior longitudinal ligament through which fragmented, dry, hard pieces of the nuclear material are extruded against the nerve root. This is the stage commonly referred to as "ruptured disk" and is characterized by continuous, severe pain in the distribution of the sciatic nerve.

After extrusion of the nuclear material the softened intervertebral disk is gradually compressed, dries out and becomes thinner. The vertebra above gradually settles down upon the one below and the articular facets become locked, preventing free motion in the joint. Then follow the reparative changes of ankylosis of the facets with marginal hypertrophic spurs from the vertebral bodies, leading ultimately to solid fusion of the entire intervertebral joint. In some cases the remaining parts of the disk and extruded fragments of the nucleus become calcified.

Each stage of disk degeneration may be marked by characteristic symptoms and signs, but in many cases the changes progress so gradually that only minor symptoms develop and may pass unnoticed by the patient. Symptoms referable to disk lesions are seldom noted in patients under 20 years of age. Clinical pictures commonly associated with the early degenerative changes of the disk, protrusions of the nucleus pulposus and complete rupture with extrusion of fragments usually occur in patients from 20 to 45 years of age. After middle age, the complaints are those which may be explained by the disintegrated, thin disk, and the partially ankylosed joint with hypertrophic changes. Such abnormal joints are naturally vulnerable to injury and to static and postural influences such as overweight, relaxed abdominal muscles and discrepancies in leg lengths. In later life, therefore, the low back problems are usually a combination of degenerative disk disease aggravated by static or postural strain or by injury.

*Protrusion of the Nucleus Pulposus.* "Protrusion of the nucleus pulposus" is the term used to designate the symptomatic syndrome associated with the early degenerative disk changes that take place prior to actual rupture of the posterior longitudinal ligament with extrusion of nuclear material into the spinal canal or intervertebral foramen. Other terms which are or have been used as diagnoses for such conditions are "incomplete rupture of the intervertebral disk," "early degenerative disk disease," "subluxation or dislocation of the sacro-iliac joint," "lumbago," "myositis," "myofascitis," and "fibrositis." Sacro-iliac displacements and affections of the lumbar muscles and fascia are no longer accepted as probable causes for the symptom complex to be described.

*Occurrence.* Protrusion of the nucleus pulposus occurs most frequently in white males under 45 years of age. It is observed less often in women and is rarely seen among Negroes. Stocky people with heavy musculature who are accustomed to heavy manual labor seem less susceptible than taller persons with less well developed muscles who do heavy lifting only occasionally.

*History.* The characteristic story is of recurrent episodes of severe, disabling low back pain, usually unilateral, often unrelated to injury, lasting from several days to several weeks and followed by variable intervals of weeks, months or years during which there are no symptoms whatever. The sudden onset with severe pain and the sensation of "something being out of place in the back," together with the prompt, although usually temporary, relief resulting from massage and manipulation of the back, and

sacral region usually reveal the same findings described under *Protrusion of the Nucleus Pulposus.*

*Treatment.* Conservative measures such as were outlined for protrusions are indicated for prolapse of the disk. Only after these have proved unsuccessful should the operation for removal of the prolapsed disk be undertaken.

### THE LOWER EXTREMITY

#### FRACTURES

*Fractures of the Hip and Femur.* Fractures of the hip and femur are major surgical problems that require hospital care.

*Fractures of the Patella.* A simple linear fracture of the patella without displacement may be treated by application of a plaster cast extending from the ankle to the upper thigh with the knee fully extended. If the knee is distended with an effusion of blood it should first be aspirated and then a compression bandage should be used for 24 hours. A circular plaster then may be applied in the following manner. The leg is painted with Ace adherent and encased in a stockinet tube extending from the ankle to the groin. Cuffs of felt 2 inches wide are taped in place above the ankle and around the upper thigh. The patella is protected by a small square of felt or a few layers of sheet wadding, and circular turns of 4-inch plaster bandage are then applied to form a cylinder that extends from the ankle to the upper thigh, leaving the foot free for walking. At the upper and lower margins of the plaster the stockinet is turned back and incorporated in plaster to prevent its slipping down over the ankle as the patient walks. If Ace adherent is not available, long strips of wide adhesive may be applied to the inner and outer surfaces of the thigh and leg running down to the foot. As the plaster at the lower edge is being completed, the stockinet and strips of adhesive can be turned back and incorporated with the last few turns of plaster. Use of the plaster cylinder should be continued for three or four weeks. After removal of the plaster the patient may use the knee actively and take exercises that will strengthen the quadriceps and overcome the moderate stiffness that follows immobilization of the knee.

Comminuted fractures of the patella and transverse fractures with separation of the fragments are major surgical problems requiring operative fixation or excision.

*Fractures of the Tibia.* Incomplete fractures of the shaft of the tibia, especially in children, can be treated by the application of a padded plaster cast extending from the toes to the groin with the knee in slight flexion. Being incomplete, these fractures do not displace easily, and the intact fibula also acts as a splint to prevent displacement.

Pseudofractures sometimes occur in the upper third of the tibial shaft of children between the ages of 4 and 14 years and are thought to be similar to the march fractures of the foot.[6] They should be treated by immobilization for six weeks in a plaster cast extending from the toes to the upper thigh.

*Fractures about the Ankle.* Fractures in this region may be treated in the office or clinic only if there is no displacement. These include undisplaced fractures of the internal or external malleolus and occasionally an isolated chip fracture of the posterior malleolus. If considerable swelling is present, elevation of the extremity and use of cold compresses or an ice bag are helpful for the first 24 or 36 hours, after which a padded plaster cast should be applied from the toes to the knee. A walking heel usually can be added to the cast after the plaster has dried, provided the pain and swelling have subsided. A solid rubber walking heel is not only most comfortable but it also does not scratch the floors as do some of the other types of walking devices. If considerable swelling is present at the time the plaster cast is applied, it will be necessary to defer weight bearing. Later, a snugly fitted plaster with a rubber heel may be applied and walking permitted after it is dry. Immobilization for six to eight weeks is generally required for these fractures to heal.

place in the logical treatment of early disk lesions. Manipulations likewise have only limited usefulness; definite indications for their use are lacking, at best they can give only partial or temporary relief and are known to aggravate or seriously cripple in certain others. Moreover, bed rest and fixation are known to provide lasting benefit and will not aggravate the condition in any case.

Most patients plead for some sort of ambulatory treatment. Physical therapy measures and adhesive strapping or corseting, with medications to ameliorate the pain, are often sufficient to enable the patient to carry on part time with a sedentary or light occupation. Thus, he may tolerate the discomfort of a single episode for several days to several weeks, but in doing so, he forfeits the possibility of obtaining firm healing and fibrosis of the annulus sufficient to prevent recurrences.

***Rupture or Prolapse of the Intervertebral Disk.*** These terms are used to designate the stage of degenerative disk disease wherein the annulus fibrosus and the posterior longitudinal ligament are ruptured and the nuclear material is extruded into the spinal canal or intervertebral foramen where it impinges upon the cauda equina or one of the nerve roots. This stage is characterized by pain along the course of the sciatic nerve.

*History.* Usually there is a history of preceding episodes of severe unilateral back pain with intervals of complete freedom from symptoms Sometimes, however, the onset is sudden with a combination of low back and sciatic pain, the latter persisting and becoming dominant. Approximately 60 per cent of patients will relate their initial complaints to some injury, but in many of these the relationship is questionable. Perhaps a slight injury was the exciting cause, but degeneration of the disk and nucleus must have occurred gradually for a long time before. Often the pain is first noted in the buttocks and upper thigh but soon becomes worse in the calf of the leg and in the foot. It soon becomes severe and constant regardless of activity or treatment. It may be relieved when the patient lies down in certain positions but never entirely disappears. Although the patient may note some stiffness and limitation of back movements and inability to stand erect, he usually considers the back pain relatively minor and the leg pain as disabling. Coughing, sneezing or straining at stool usually aggravates that pain.

*Examination.* The patient appears well except for the disability of his back and leg. He stands with most of his weight on the uninvolved leg, the lumbar curve is flattened, the trunk usually lists to the unaffected side, the lumbar muscles are taut, and all bending movements are limited. If the sciatic pain is severe the patient walks with a limp favoring the involved leg.

In the sitting position the trunk list may be less apparent and bending movements slightly freer but still limited. There is tenderness to deep pressure over the spinous processes of the fourth and fifth lumbar vertebrae and over the lumbosacral angle on the affected side. Reflexes at the knees are normal but the ankle jerk on the affected side may be diminished or absent. Some weakness of the plantar flexors or dorsiflexors of the foot, depending upon the nerve root affected, and sensory changes to light touch and pin prick over the lateral aspect of the leg and foot are frequently present.

With the patient supine, straight leg raising on the affected side to an angle of more than 30 to 40 degrees from the table intensifies the sciatic and back pain. The patient usually resists further elevation because of severe pain. The same test applied to the opposite side may produce less severe pain in the back and in the affected leg, but only when elevated much higher than was possible on the affected side. Complete flexion of hips and knees with pelvic movement usually produces both back and leg pain.

Myelograms and spinal fluid examinations are generally considered unnecessary except to differentiate this lesion from a possible tumor of the spinal cord.

Routine roentgenograms of the lumbo-

occurs in the second metatarsal, although it sometimes occurs in the third or fourth. Such fractures often were seen in troops in their training periods during World War II. They develop insidiously as the result of long-continued walking or standing. The patient complains of the gradual onset of pain and swelling of the dorsum of the foot. The lesion may be overlooked in early roentgenograms, but later ones reveal a transverse fracture with a spindle-shaped mass of callus surrounding the fracture line. Occasionally, these have been mistaken for neoplasms, as no definite history of trauma can be elicited. Treatment by use of a metatarsal bar on the sole of the field boot is usually sufficient. Occasionally the pain and swelling may be severe enough to require a short period of bed rest followed by use of a walking plaster for four to six weeks.

## Acquired Conditions and Injuries Other than Fractures

### *Diseases and Injuries about the Hip*

Injuries of the hip joint itself usually require treatment in the hospital. However, there are certain acquired conditions in the region of the hip resembling traumatic lesions which require differentiation before recommendations for adequate treatment can be made.

*Synovitis of the Hip.* Synovitis of the hip is usually due to injury or strain of the joint. It may be associated with structural changes in the joint, such as traumatic or hypertrophic arthritis or coxa plana, or it may be due to a low grade infectious process with superimposed strain. The patient usually holds the hip flexed and adducted and walks with a limp because of the pain. Clinical manifestations include muscle spasm, which is a constant finding, and pain upon pressure over the anterior aspect of the hip joint and over the greater trochanter. The condition must be differentiated by roentgenographic examination from acute or subacute epiphysitis, slipping of the upper femoral epiphysis, and Perthes' disease. Clinically it must be distinguished from iliopsoas bursitis and pyogenic infection of the hip.

Treatment includes rest and local applications of heat. If the pain is severe, traction or, occasionally, immobilization in a plaster of paris spica may be required. Aspiration of the joint is essential if a pyogenic infection is suspected.

*Bursitis in the Region of the Hip.* The relationship of trauma to the occurrence of acute bursitis in the region of the hip is questionable. However, confusion with traumatic conditions is so frequent that the three bursae of clinical importance should be mentioned.

*Trochanteric Bursae.* Both the superficial and the deep trochanteric bursae may be involved. The latter is located behind the greater trochanter and in front of the insertion of the gluteus maximus muscle. Physical examination reveals obliteration of the normal depression behind the greater trochanter, with exquisite tenderness in this area. The leg is usually held in a flexed, abducted and externally rotated position which relaxes the tension upon the gluteus maximus muscle. Occasionally, pain may extend down the back of the thigh, and any motion of the hip joint may cause discomfort.

The superficial trochanteric bursa is located between the greater trochanter and the skin. Tenderness and swelling may be present over the bursa, and frequently pain is experienced on abduction of the leg against resistance. If calcium can be demonstrated roentgenographically in the bursal region, superficial roentgen-ray therapy, similar to that given in subdeltoid bursitis, is an easy, prompt method of relieving pain. Injection of procaine or hydrocortisone in the bursal area, combined with heat and rest, is generally sufficient for those cases in which no calcium can be demonstrated. Occasionally the bursitis becomes chronic and requires surgical excision.

*Iliopectineal-iliopsoas Bursa.* This bursa is located between the iliopsoas muscle and the iliopectineal eminence of the ilium on the anterior surface of the hip joint capsule and frequently com-

A sprain or rupture of the inferior tibiofibular ligament sometimes occurs without a fracture of the malleoli and results in varying degrees of lateral luxation of the ankle. Swelling and tenderness are present over the tibiofibular joint and there is instability of the astragalus in the ankle mortise which becomes apparent after injection of a 2 per cent solution of procaine hydrochloride in the region of the tibiofibular ligament. After injection, roentgenograms made with the foot strongly inverted reveal separation of the tibiofibular articulation and subluxation of the astragalus. This injury requires a longer period of immobilization than an ordinary sprain or sprain fracture, and internal fixation across the distal tibiofibular articulation is sometimes required to maintain stability of the ankle joint.

*Fractures of the Tarsal Bones.* These generally are the result of a severe injury and are frequently complicated by dislocations of adjacent joints. Therefore they require manipulation under general anesthesia or open reduction and are major surgical problems.

*Fractures of the Metatarsals.* Fractures of the shafts of the metatarsals are rarely displaced to an appreciable extent, and adjacent metatarsal shafts act as effective splints. Single fractures with a minimum of soft tissue involvement can be effectively treated with adhesive strapping around the forepart of the foot and the addition of a metatarsal bar to the sole of the shoe. Multiple undisplaced fractures of the shafts with considerable soft tissue swelling will require rest and elevation of the bandaged foot until the swelling subsides. Then a lightly padded, carefully molded plaster boot can be applied and later a walking heel. Weight bearing in a walking plaster should be continued for six weeks, and then in a shoe with a support under the longitudinal arch and a metatarsal bar on the sole.

Avulsion fracture of the proximal end of the fifth metatarsal, caused by excessive pull of the peroneus brevis, sometimes occurs and is known as a tennis fracture. The diagnosis is suggested by local tenderness at the base of the fifth metatarsal and is confirmed by x-ray examination. There is no epiphysis at the proximal end of the fifth metatarsal, even in children, but occasionally an accessory bone known as the os peroneum may be seen and should not be confused with a fracture. Treatment consists of immobilization in a lightly padded plaster boot with walking heel for four weeks. Adhesive strapping is not sufficient to relieve the pain, which is due to the pull of the peroneus brevis tendon.

*Fractures of the Phalanges.* Fractures of the phalanges occur from direct violence, either from a heavy object falling upon the toes or by striking the bare toes against a hard object. The toe quickly swells, becomes discolored and is very tender. Roentgenograms usually reveal a fracture with little or no displacement; hence reduction is not required. Splinting is unnecessary but the toe must be protected from pressure while it is swollen and tender and is more comfortable if covered with adhesive tape that extends onto the sole and dorsum of the foot for about 2 inches. The patient can bear weight on the foot if he wears a shoe with a firm sole and cuts away the upper part over the involved toe. Some prefer to strap the involved toe to the adjacent digits with a bit of cotton placed between them. For fractures of the proximal phalanx it is also helpful to strap a felt metatarsal pad to the sole of the foot just behind the metatarsal heads.

*Fracture of a Sesamoid Bone.* These fractures are rare but may occur in jumping and landing on the ball of the great toe. They are characterized by swelling and tenderness beneath the head of the first metatarsal. Roentgenograms often reveal a congenital, bipartite sesamoid which may be mistaken for a fracture. When a definite diagnosis of fracture is established, excision of the involved sesamoid is advisable. Conservative measures usually result in persistent pain from excessive callus formation even if union is secured.

*March Fracture (Fatigue Fracture, Stress Fracture).* This fracture usually

owing to collapse of the head and is associated with some broadening and shortening of the neck. This pathologic process requires from 30 to 40 months for completion.

The clinical picture is characterized by a constant limp, which is the earliest sign. This may or may not be associated with muscular spasm and pain. Pain is occasionally referred to the knee, and there develops gradual limitation of motion of the hip, particularly rotation and abduction. There is usually some atrophy of muscles about the hip and thigh and slight shortening, usually not more than one-half or three-fourths of an inch. During the stages of repair the signs and symptoms become less severe, and only a mild limp may be present with rather severe roentgenographic changes.

Roentgenograms (Fig. 171) of both hips should always be made in a suspected case. Both anteroposterior and lateral projections are essential for accurate diagnosis in early cases.

Primary consideration in treatment is rest and protection from weight bearing. This may be accomplished in many ways. In the acute phase, if pain and muscle spasm are present, bed rest in traction is necessary. Ideally, complete relief from weight bearing should be enforced for two years or more during the entire period of degeneration and regeneration by keeping the child in a bed and wheel chair. However, since the child is otherwise well and active, most orthopedists compromise with the ideal and attempt to protect the affected hip from weight bearing by one of the following plans. When the acute symptoms subside, weight bearing is avoided by the use of crutches and by lengthening the normal leg with a special shoe that has a two-inch lift on the sole. Others provide a sling to hold the affected leg in the flexed position and have the child walk with crutches. Still others use on the affected side an ischial weight-bearing brace with the bars extended two or three inches below the foot, and compensate for the added length by providing a high soled shoe for the opposite foot. One or another of these appliances should be used until the process of regeneration is revealed to be complete in serial roentgenograms.

*Diseases and Injuries about the Knee*

Good treatment of injuries about the knee requires an accurate diagnosis made by careful routine examination. The entire left thigh should be exposed with the patient lying down to provide relaxation of the thigh muscles. After



*Figure 171.* Legg-Perthes' disease. Note the flattened head, dense epiphysis and wide femoral neck in contrast to the normal hip on the opposite side.

municates with the joint cavity. Diagnosis is generally made on the presence of exquisite localized pain and tenderness directly anterior to the femoral head, with no pain or tenderness elsewhere about the hip, and pain on attempt to extend, adduct or internally rotate the hip. Injection of 10 to 15 cc. of a 1 per cent solution of procaine hydrochloride will generally produce relief.

*Ischiogluteal Bursitis (Weaver's Bottom).* Located superficial to the tuberosity of the ischium, this bursitis develops in weavers, boatmen and persons whose occupation necessitates prolonged sitting upon hard surfaces. Acute tenderness along the tuberosity of the ischium is generally found. Relief is usually obtained with injection of procaine into the bursal area and use of superficial roentgen-ray therapy. Persistence of the condition occasionally indicates complete excision of the bursa.

***Slipping of the Capital Femoral Epiphysis (Epiphyseal or Adolescent Coxa Vara).*** This condition is most often observed in children between the ages of 10 and 16 years and occurs most frequently in boys. In the majority of cases there is history of trauma, which is often trivial, and most investigators believe that in all cases a vascular disturbance at the epiphyseal line precedes the actual slipping or displacement of the epiphysis. As a result of this underlying epiphysiolysis, trauma of slight to violent degree may cause loosening and displacement of the epiphysis. The head of the femur becomes displaced inferiorly and posteriorly on the neck and is generally unilateral if trauma is the exciting cause. Outstanding symptoms are fatigue after walking or standing, pain, stiffness and limp, and pathognomonic of the condition is the development of fixed external rotation of the extremity and shortening. These symptoms may develop gradually if there is no trauma or may develop immediately after a fall from a tree or injury at play.

Characteristic physical findings are restriction of internal rotation and shortening of the extremity, restriction of abduction and pain on movement of the hip. When the hip is flexed, it tends to abduct and rotate externally. Tenderness may be present about the anterior and lateral aspects of the hip. Not infrequently the discomfort first consists of referred pain to the knee but later the pain is located only at the hip joint. The prodromal or preslipped stage consisting of widening of the epiphyseal line, the diagnosis of which is dependent upon adequate roentgenographic interpretation, is the most favorable time for treatment. Unfortunately, patients are seldom seen at this stage.

Treatment is beyond the scope of minor surgery but recognition in the early stages before much slipping has occurred is imperative for a satisfactory functional result after treatment. In the preslipped stage or in the stage of minimal slipping, fixation with a three-flanged nail, a metallic pin or bone graft has usually given satisfactory results. In cases with greater slipping, osteotomy of the femoral neck is necessary to correct displacement. These cases present a much more difficult therapeutic problem and the results are much less satisfactory than those in the former class.

***Coxa Plana (Legg-Perthes' Disease, Avascular Necrosis of the Capital Femoral Epiphysis).*** This condition consists of flattening of the epiphysis at the head of the femur due to osseous changes generally interpreted as avascular necrosis of the epiphyseal region. It occurs usually in children between the ages of 4 and 12 years and is more common in boys. The etiologic factors underlying the pathologic changes have not been definitely established. The majority of observers believe that trauma or strain is a primary factor, but endocrine disturbance and low grade infection have been cited as contributing etiologic factors. A definite pathologic change occurs in each case, consisting of necrosis of subchondral bone that gradually progresses to involve the entire epiphysis of the femoral head which, in roentgenograms, appears to be fragmented and flattened. The epiphysis is finally reorganized into a smooth mass of bone which may be considerably deformed

knee shortly after the accident, especially when there is effusion in the joint. The diagnosis should be deferred for a day or two and treatment instituted by aspiration, application of a compression bandage, bed rest with elevation of the knee and leg, and administration of sedatives. Fixation in plaster or use of traction may be indicated for severe cases. After a day or two the pain and tenderness usually subside enough to permit diagnostic manipulations. However, if there is still a question of stability of the knee, the patient should be given a general anesthetic and the knee can then be freely manipulated to determine the presence of a rupture of the lateral or cruciate ligaments, and subsequent treatment then can be outlined with assurance.

*Traumatic Synovitis and Hemarthrosis.* Most injuries to the knee cause an increased amount of synovial fluid (water on the knee) or bleeding into the synovial cavity (hemarthrosis). Either of these causes pain by distention of the capsule, and prevents early active motion of the knee. Blood that is allowed to remain in the joint requires a long time for absorption and produces adhesions and stiffness of the joint. Excessive amounts of fluid and blood should be aspirated under sterile conditions, following which a compression bandage should be applied together with a posterior splint to prevent motion, and the patient should rest in bed. When the acute symptoms have subsided he may be allowed to be up and about with the aid of crutches.

*Fracture of Semilunar Cartilages.* Fracture or tear of the semilunar cartilages accounts for approximately 80 per cent of all internal derangements of the knee, and the internal semilunar cartilage is injured about eight times as often as the external cartilage. The mechanism of injury usually is by forcible abduction and rotation of the leg when the knee is flexed and the foot fixed. If the cartilage is torn loose from its marginal attachments it may be displaced towards the midline of the joint in such position that it prevents full extension and thus "locks" the joint. When this occurs, the knee can often be unlocked by flexing it to 90 degrees and rotating the leg inwards and outwards on the femur and at the same time gradually straightening the knee. Sometimes this manipulation for repositioning the cartilage may be performed without a general anesthetic but when there is acute pain and spasm of the muscles anesthesia is required. When the manipulation replaces the torn cartilage the knee can be fully extended without resistance or production of pain.

Initial tears of the internal semilunar cartilage should be suspected when the patient describes the mechanism of injury as one that involves flexion, abduction and rotation of the knee when the foot is fixed. Often he describes a tearing sensation or sharp pain on the inner side of the joint and immediately thereafter he is unable to walk except with the knee in a flexed position. Swelling of the knee develops rapidly, the pain becomes more generalized and all joint movement becomes painful. On examination the knee is found to be flexed to 160 degrees to 180 degrees, and voluntary or passive extension beyond this causes severe pain. The knee is distended with fluid and there is localized swelling and acute tenderness over the inner part of the joint line. Rupture of one of the supporting ligaments of the knee is sometimes associated and should be excluded before definitive treatment is undertaken.

*Treatment.* Conservative measures should be tried in every initial meniscal injury when the knee is not locked or can be successfully unlocked. This consists in the application of a plaster cylinder with the knee fully extended. (For details of application see *Fracture of the Patella.*) The plaster should be worn for three to six weeks and the patient may be ambulatory. On removal of the plaster he should have treatments with heat and massage applied to the knee, active and passive motion, and exercises for strengthening the quadriceps muscle.

If the knee joint cannot be unlocked after the initial injury, it is useless to

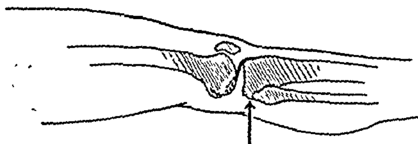


*Figure 172* Test for rupture of the anterior cruciate ligament The anterior cruciate ligament is tense when the knee is extended The ligament extends from the anterior edge of the tibia to an extensive insertion at the posterior part of the medial aspect of the lateral femoral condyle. When this ligament is ruptured the tibia may be moved forward on the femur when the knee is extended.

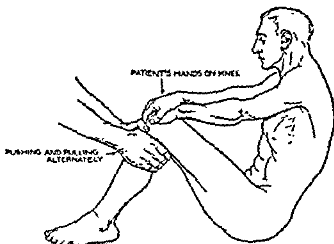



*Figure 173.* Test for rupture of the posterior cruciate ligament If the knee is held steady in 90 degree flexion, the posterior ligament is tense, and backward motion of the tibia on the femur is prevented. If the ligament is ruptured, the tibia may be moved backward on the femur. (From Forrester, C. R G Imperative Traumatic Surgery New York, Paul B. Hoeber, Inc.)

inspection of the knee the active and passive ranges of motion should be determined. Incomplete extension may be due to spasm of the muscles produced by pain or to a mechanical blocking of the joint. If the presence of a joint effusion is causing spasm of the muscles, full extension may be obtained without severe pain by slow, gradual stretching. If the joint cannot be brought into full extension by steady, slow stretching it is because of mechanical obstruction or some internal derangement of the knee joint. Presence of excessive fluid in the joint is detected by fullness of the quadriceps pouch and a click of the patella as it is pressed against the femoral condyle. The circumference of both thighs should be measured at corresponding levels. The laxity of the lateral ligaments may be determined by adducting and abducting the extended knee. The integrity of the cruciate ligament is checked by flexing the knee and fixing the foot, then grasping the proximal end of the tibia with both hands and moving it backward and forward on the femur. Excessive movement in the anterior direction on drawing the tibia forward is indicative of rupture of the anterior cruciate ligament (Fig. 172), whereas abnormal movement in the posterior direction is indicative of damage of the posterior cruciate ligament (Fig. 173). The sites of pain and tenderness should be accurately determined, and it is important to differentiate tenderness over the anteromedial joint line from that over the insertion of the internal lateral ligament. Examination is completed by roentgenograms made in the anteroposterior and lateral planes as well as special "notch views" if loose bodies or lesions of the intercondylar notch are suspected.

It is often impossible to make an exact diagnosis of the extent of injury to a

semilunar cartilage, or forced hyperextension of the knee causing internal rotation of the tibia on the femur, and rupture of the internal lateral ligament may at the same time rupture the anterior cruciate ligament. Murray[9] stated that he had never seen a patient with a tear of the anterior cruciate ligament showing any physiologic disturbance of articular function if the power of the quadriceps mechanism had been restored by active treatment.

The posterior cruciate ligament prevents the femur from gliding unduly forward during weight bearing. It is ruptured when the knee joint is completely dislocated, or it may be ruptured by a force which displaces the tibia backward on the femur while the knee is flexed.

Ruptures of both posterior and anterior cruciate ligaments are best treated conservatively by aspiration of the knee [illegible] at 140 degrees of extension for eight to twelve weeks in a long leg plaster; then active exercises should be used to regain motion and strengthen the quadriceps mechanism.

***Fracture of the Tibial Spine.*** Avulsion fracture of the tibial spine is usually caused by the same mechanism as that which produces rupture of the cruciate ligaments. Injury is immediately followed by severe swelling of the joint, tenderness, pain, and inability to extend the knee completely. The diagnosis can be confirmed by roentgenograms.

For minimal displacement of the fragment, aspiration followed by immobilization in extension for four weeks and followed with quadriceps exercises may be sufficient. However, if the fragment is displaced so as to block extension and cannot be repositioned by manipulation so as to permit complete extension, surgical measures are indicated for fixation or excision of the fragment.

***Hypertrophy of Infrapatellar Fat Pad.*** Enlarged fat pads posterior to the patellar tendon may be traumatized and pinched when the knee is extended. Repeated trauma of this type will produce organized fibrous tissue that occasionally may become calcified. The patient complains of pain on extending his knee and tenderness beneath the patellar tendon. Treatment consists of restricting activity and elevating the heel of the shoe and, later, exercises to restore the strength of the muscles about the knee. Occasionally, if symptoms persist, removal of the fat pad is indicated.

***Osteochondritis Dissecans.*** Osteochondritis dissecans occurs more often in the knee than in any other joint. Some authorities believe it is initiated by trauma. It is characterized by partial detachment of a fragment of cartilage and underlying bone from the femoral condyle and, in chronic cases, the fragment may become completely detached and extruded into the knee joint, leaving a defect or shallow crater in the articular surface of the medial condyle. The patient complains of discomfort, weakness, fatigue of the knee, and sometimes of its catching or locking. On examination there are few physical signs, but sometimes pain can be elicited by pressing upon the patella when the knee is fully flexed. The lesion is visualized in roentgenograms, especially in "notch views." Excision of the fragment usually gives prompt relief.

***Chondromalacia of the Patella.*** This condition is receiving more attention as the pathologic changes are becoming better understood. Fibrillation or aseptic necrosis of the cartilage of the patella with erosion extending into the subchondral bone is a fundamental pathologic change that usually seems to be initiated by trauma. The symptoms are pain on extending the knee, as when climbing stairs, accompanied by intermittent joint effusions. A catching sensation is often present but no true locking occurs. Pain can be elicited by pressing the patella against the femoral condyles as the knee is flexed and extended. If simple measures of physical therapy and temporary immobilization of the joint fail to prevent periodic exacerbations, operative measures are indicated for shaving off the degenerated cartilage or excising the patella in severe cases.

immobilize the flexed knee in plaster, and the patient should be advised to consult a surgeon who can remove the torn meniscus at an early date.

*Cysts of Semilunar Cartilages.* Cysts of semilunar cartilages are thought to represent (1) the end result of a localized degenerative process in the cartilage, (2) a congenital defect of the development of the cartilage, or (3) a ganglion-like structure resulting from trauma between the peripheral surface of the cartilage and the synovial membrane. The cysts, which are more often multiple than single, contain a soft gelatinous material, and are about eight times more common in the external cartilage than in the internal cartilage. The cyst may become larger after an injury to the knee. Signs and symptoms are similar to those of injury of the semilunar cartilage except that there is usually no locking or sudden effusion. The slightly tender swelling becomes more apparent when the joint is extended and tends to recede as it is flexed. Occasionally, a cyst can become large enough to exert some pressure on the peroneal nerve, producing symptoms over the peroneal distribution. Complete excision of the cyst and affected cartilage is indicated.

*Injuries to the Lateral Ligaments of the Knee (Sprains and Ruptures).* Injuries to the lateral ligaments of the knee joint are the result of forceful abduction or adduction (Fig. 174). Since the knee is more exposed to trauma from abduction than adduction, the internal lateral ligament is injured more frequently than the external. The resulting injury may be a simple sprain which occurs often when playing football or skiing. Examination shortly after injury may reveal some fluid in the joint, maximum tenderness at the origin of the collateral ligaments about one inch above the joint line, some limitation of extension and pain on abducting or adducting the knee. There is no lateral instability unless the ligament is ruptured. The patient should remain in bed with his leg elevated and a compression bandage applied to his knee for a day or two after injury. Thereafter he may have a plaster cylinder applied, and be permitted to bear weight and walk. The protective plaster should be continued for three weeks and suitable physical therapy measures then started.

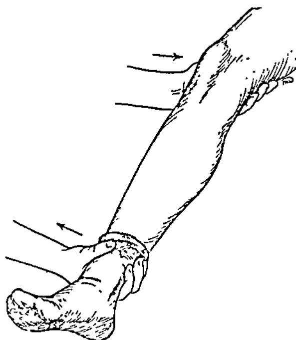


*Figure 174.* Test for injury to the internal lateral ligament of the knee. The test is reversed when the external ligament is examined.

Complete rupture of the internal lateral ligament is a serious injury evidenced by abnormal lateral mobility of the joint in full extension. Swelling and tenderness are present and a defect may be palpated in the ligament. Effusion of blood and fluid in the joint is not great because it escapes through the gap into the subcutaneous tissue. The anterior cruciate ligament may be ruptured at the same time as the lateral ligament and if pain and muscle spasm prevent an accurate diagnosis, the knee should be examined under anesthesia. There is increasing evidence that prompt early surgical repair of a complete rupture of the lateral ligaments results in earlier resumption of activity than does prolonged immobilization in plaster. Quigley[7, 8] considers 15 degrees of abduction or adduction as a criterion for immediate surgical repair and his results have been most gratifying.

*Injuries to the Cruciate Ligaments.* The anterior cruciate ligament may be damaged by the same type of trauma as that which causes injury to the internal

semilunar cartilage, or forced hyperextension of the knee causing internal rotation of the tibia on the femur, and rupture of the internal lateral ligament may at the same time rupture the anterior cruciate ligament. Murray[9] stated that he had never seen a patient with a tear of the anterior cruciate ligament showing any physiologic disturbance of articular function if the power of the quadriceps mechanism had been restored by active treatment.

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Figure 175 Pellegrini-Stieda disease. (Rachlin, N. H J Bone & Joint Surg, 16 716, 1934)

***Calcification of the Tibial Collateral Ligament (Pellegrini-Stieda Disease).*** This is fairly common after a single injury or repeated minor injuries to the joint. Deposits of calcium occur in the midportion of the tibiocollateral ligaments and about the mediofemoral condyle. The knee may be swollen, complete extension is painful and there is tenderness over the medial aspect. The roentgenographic appearance is pathognomonic (Fig. 175). Treatment consists in rest and support for the knee during the acute stages, followed by suitable measures of physical therapy. In many cases symptoms subside spontaneously. Excision is occasionally done in chronic cases but the results are not encouraging.

***Rupture of Quadriceps Tendon and of the Patellar Ligament.*** Either of these structures may be ruptured by sudden violent contraction of the quadriceps muscle when the knee is flexed. Rupture of the quadriceps tendon occurs oftener than rupture of the patellar ligament and both are more common in older people. When the quadriceps tendon is ruptured, a depression may be palpated above the superior margin of the patella and there are signs of trauma about the knee joint. Rupture of the patellar tendon results in upward displacement of the patella and tenderness below the knee. A depression can usually be palpated just below the knee but it may be obscured by swelling. After complete ruptures the patient is unable to extend the knee actively and after incomplete ruptures extension is extremely painful. It is necessary to differentiate these ruptures from other traumatic lesions about the knee, such as fractures of the patella, hemarthrosis and traumatic effusions, because they require immediate surgical repair.

***Osgood-Schlatter Disease (Osteochondritis of the Tibial Tubercle).*** This is a frequent cause of pain about the knee in boys between ten and fifteen years of age and is often bilateral. The underlying etiologic factor is disturbance of the circulation of the epiphysis, probably aggravated by trauma. The patient complains of pain on the anterior surface of the tibia just below the knee after exercise or on kneeling. Examination reveals abnormal prominence and tenderness of the tibial tubercle. Extension of the knee against resistance produces pain in the region of the tubercle. Roentgenograms usually reveal fragmentation and separation of the tubercle, but at times no radiologic changes can be demonstrated and the diagnosis must be made on clinical observations. Treatment consists in limitation of the patient's activities, principally those which bring stress on the insertion of the patellar tendon. If symptoms are acute, a plaster cylinder should be applied from ankle to groin as described under *Fractures of the Patella*. Milder cases may need only an elastic bandage around the knee or adhesive strapping to hold the knee in extension. The disease eventually subsides spontaneously but this may require months or even years.

***Discoid Cartilage of the Knee.*** This is a congenital developmental anomaly in which the meniscus is disk-shaped. It produces pain and a definite clicking or thud in the region of the external meniscus on weight bearing. Symptoms are due to inability of the articular surface

anomalous meniscus. Treatment is surgical excision.

*Bursitis about the Knee.* Eighteen or more bursal sacs about the knee have been described but few are of clinical importance. The bursae most commonly affected are: (1) prepatellar (housemaid's knee), (2) deep infrapatellar, (3) superficial pretibial, and (4) popliteal.

*The prepatellar bursa* occupies the superficial area between the midportion of the patella and the midportion of the patellar ligament (Fig. 176) and often becomes inflamed from the irritation of repeated or prolonged kneeling. In the early acute stages aspiration, application of a compression bandage, and prevention of further trauma will usually relieve the symptoms. However, if the bursa becomes chronically thickened and tender, it should be excised.

*The deep infrapatellar bursa* is situated between the lower portion of the patellar ligament and the tibia. When the bursa becomes swollen, the normal depressions on either side of the patellar tendon disappear; active flexion and extension of the knee are painful and limited. Treatment is similar to that for a prepatellar bursa.

*The superficial pretibial bursa* overlies insertion of the patellar ligament into the tibia. It may be similarly involved and treated.

*The popliteal bursae* are numerous The semimembranosus bursa (popliteal or Baker's cyst) is of most clinical importance. It may fill the popliteal space and become large enough to interfere with flexion of the knee. The anserina bursa which lies between the semitendinosus and gracilis tendons and the tibia may become distended and painful at times. Variable bursae, described by Voshell and Brantigan, are located beneath the tibial collateral ligament and may cause localized swelling, pain and disability. This often can be relieved by an injection of procaine into the region of the involved bursa.

The enlarged popliteal bursa (Baker's cyst) requires an excision performed under general or spinal anesthesia. A bloodless operative field may be had by use of a tourniquet and this simplifies the task of locating and tying off the communication between the bursa and the joint that usually is present.

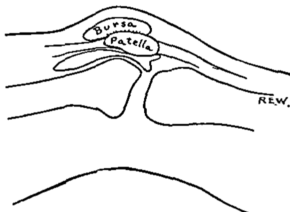



*Figure 176* Diagram to show the common location of the prepatellar bursa in "housemaid's knee"

### *Injuries about the Ankle*

*Strains and Sprains.* A strain is usually defined as a rupture or injury of muscle fibers, and a sprain as injury in which a ligament about a joint is forcibly stretched or completely torn without a dislocation. A sprain is more serious than a strain. Sprain of the ankle is usually incurred by violent inversion of the foot with a tear of the anterior and middle fasciculi of the anterior lateral ligament. Less commonly, the foot may be violently everted, spraining the deltoid ligament. Manifestations of ankle sprain are localized pain, swelling, ecchymosis, and sharply localized tenderness over the injured ligament. Weight bearing may be impossible. Active and passive inversion of the foot is painful if the lateral ligaments of the ankle are sprained and eversion of the foot is painful when the deltoid ligament has been injured.

Direct pressure on the heel or foot in the long axis of the leg is seldom painful in sprains but is extremely painful in fractures about the ankle. Roentgenograms should always be made to differentiate a sprain from a fracture, for the protection of both the patient and the physician. Rupture of the distal tibiofibular ligament should also be excluded, as this leads to tibiofibular diastasis. If

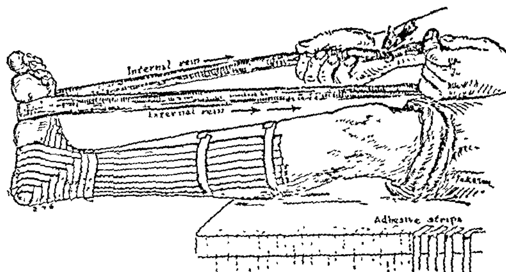



*Figure 177.* Gibney adhesive strapping for sprained ankle For sprains of the external lateral ligament, stronger traction is made upon the external *rein* to secure eversion of the foot. For sprains of the internal lateral ligament the opposite procedure is followed.

rupture of the tibiofibular ligament is suspected, the tender areas should be injected with procaine and roentgenograms made with the foot in forced inversion as described *under Fractures about the Ankle*

Adhesive strapping of the ankle is the generally accepted method of treatment. The Gibney method (Fig. 177) is very useful The skin about the foot and ankle should be painted with tincture of benzoin or Ace adherent to minimize irritation from the adhesive tape. The patient should hold his foot in its most comfortable position by holding both ends of a strip of bandage passed under the ball of the foot. He should thus hold the foot in dorsal flexion and either invert or evert the foot to relax the injured ligaments. Longitudinal or transverse strips of 1 inch adhesive tape should be applied to the ankle in the manner illustrated in Figure 177, and bound with turns of gauze bandage over the tape The strapping should be extended to the metatarsophalangeal joints in order to prevent excessive swelling of the toes distal to the adhesive tape. After a mild sprain, active weight bearing on the supported ankle is conducive to early absorption of hematoma and dispersion of swelling, so that recovery is more rapid than if the patient walks on crutches. The strapping should be replaced as soon as it becomes loose, usually in three or four days, and it should be worn for three weeks or until the symptoms have disappeared. For severe sprains, a plaster cast extending from toe to knee, and with a walking heel attached, is frequently the best form of treatment. With the aid of the plaster boot most patients can be ambulatory after a few days and may continue their normal activities. After removal of strapping it is often helpful to elevate the heel of the shoe one-fourth inch on the side of the injured ligament.

Many advocate injection of procaine into the injured ligament or spraying the overlying skin with ethyl chloride, followed by immediate ambulation without support. However, we believe that this treatment should be limited to very mild sprains. If the ligament has been considerably torn, as indicated by swelling and ecchymosis, support is essential.

***Rupture of the Achilles Tendon and Plantaris Muscle.*** Rupture of the Achilles tendon generally occurs in persons who indulge in violent exercise such as tennis or running. They immediately feel severe pain in the calf of the leg and if the rupture is complete, the patient is incapable of plantar flexion of the foot against resistance. The rupture generally occurs at the junction of the tendinous and muscular portions of the posterior calf group of muscles but, occasionally, it may be in the substance of the Achil-

les tendon itself if degenerative processes have preceded the acute episode. Dehiscence can usually be palpated at the site of rupture, particularly if the patient is seen before ecchymosis and swelling have become extensive. Theoretically, if accurate differentiation could be made between partial and complete rupture, treatment by immobilization in a plaster cast with the foot in plantar flexion could be used for partial tears. Because of this difficulty of differentiation, however, open surgical treatment is generally superior to nonoperative measures and the results are generally good when the treatment is instituted early. When operation is deferred, there is separation of the tendon ends with extensive scar tissue and it is often necessary to splice the defect with fascia. Therefore the results in late cases are much less satisfactory.

Rupture of the plantaris muscle, sometimes termed "tennis leg," is usually the result of violent exercise. The patient is seized with sudden pain in the calf of his leg which he says feels as if it had been shot or struck with a stone. Severe swelling and ecchymosis develop rapidly but continuity of the calf muscles can be demonstrated and differentiates this condition from a rupture of the Achilles tendon. Formerly it was customary to immobilize plantaris muscle ruptures with a plaster cast which held the foot in equinus, but recently it has been observed that patients treated with heat and counter-irritation become ambulatory as soon as acute symptoms subside and recover much more rapidly than those treated by immobilization.

### *Injuries and Diseases of the Foot*

*Acute Foot Strain.* Acute strain of the longitudinal arch is frequently seen in active young persons who must be on their feet a great deal, particularly if they are unaccustomed to standing for long periods. It also commonly occurs in patients who become ambulatory without proper shoe support after an illness that requires prolonged confinement in bed. Predisposing factors are incorrectly fitted shoes and obesity. Symptoms consist in strain or discomfort in the feet following weight bearing, and stiffness on getting up in the morning or starting to walk after resting. The elasticity of the gait is frequently lost. Pain and aching on the medial side of the ankle and about the longitudinal arch may be followed by dull aching pain in the leg, occasionally extending to the knees, hip and back. Palpation generally reveals tenderness over the plantar surface of the first cuneiform and the base of the metatarsal.

*Treatment* consists of rest in bed and hot foot baths in the early acute stage, followed by strapping of the foot and ankle as would be done for a sprain of the deltoid ligament of the ankle. An oval-shaped pad cut from ½ inch felt placed under the longitudinal arch and held in place by the strapping is more effective than simple strapping alone. Upon removal of the strapping, attention should be directed to elimination of the underlying causes, such as obesity, primary static foot defects and improperly fitted shoes, if recurrences are to be prevented.

*Metatarsalgia.* Metatarsalgia, or acute strain of the anterior arch, is characterized by cramping or burning pain under the metatarsal heads on weight bearing that may be severe enough to be disabling. It is generally relieved by rest and removing the shoes. Metatarsalgia occurs most frequently in females with short Achilles tendons who wear tight, short, high-heeled shoes. Localized tenderness is most often found beneath the fourth metatarsal head, and painful calluses may be present. The ligaments of the anterior arch are relaxed, plantar flexion of the toes is restricted, and there is pain when this motion is attempted. Frequently, other static deformities such as hallux valgus are associated. The affected joints seldom are swollen or red.

*Treatment.* Temporary relief can generally be secured by adhesive strapping, applied over a triangular shaped metatarsal pad cut from ½ inch felt. The edges of the pad are bevelled with a knife or scissors and it is placed just posterior to the painful metatarsal head.

The thickness of the pad should be adjusted so that, as the patient stands, his weight is supported on the pad and not on the metatarsal heads. If the felt pad is sandwiched between two layers of adhesive before being strapped to the foot it is less likely to slip out of place as the patient walks. Use of the metatarsal pad and strapping should be continued for two to three weeks until the acute symptoms have subsided. The patient should then wear a thick-soled shoe with ample width for the toes with a metatarsal pad inside the shoe or a metatarsal bar on the sole.

*Morton's toe* is a type of metatarsalgia described by Morton in 1876 and characterized by sudden attacks of sharp radicular pain usually confined to the area between the third and fourth toes. The condition is much more common in women than in men. Frequently, the pain is sharp and lancinating and can only be relieved by removal of the shoe and manipulation of the toes. There is complaint of paresthesia and numbness, particularly about the lateral side of the third toe and the medial side of the fourth toe. The foot usually appears normal, and diagnosis is made from the history and by reproduction of the pain on manipulation of the toes There may be exquisite tenderness when pressure is made in the third web space, which can be temporarily abolished by injection of procaine into the tender area. The symptoms are caused by a thickening or neuroma of the fourth plantar digital nerve at its bifurcation in the web space where the nerve has been traumatized by the adjacent metatarsal heads

*Treatment* Symptoms can occasionally be relieved by use of a metatarsal support or corrective shoes, but excision of the neuroma is required in the majority of cases. It is a safe procedure which provides prompt and permanent relief, but the operation is one that should be performed in a hospital.

***Hallux Valgus* (*Bunion*) (*Fig. 178*).** This is an acquired deformity characterized by lateral deviation of the great toe, with adduction and varus of the first metatarsal, enlargement of the medial side of the head of the first metatarsal bone (exostosis) and formation of a bursa overlying the bony prominence. Occasionally, bunions may be caused by a congenitally short first metatarsal bone but most result from the wearing of narrow, pointed, short-vamped shoes with high heels which tend to produce not only a bunion but also widening of the anterior part of the foot and depression of the anterior arch with accompanying metatarsalgia. The pain of hallux valgus is due to the inflamed bursa, a traumatic arthritis of the metatarsophalangeal joint and, occasionally, to displacement of the sesamoid bones

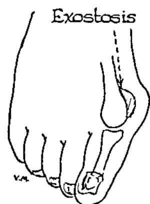



*Figure 178.* Hallux valgus (bunion)

*Treatment.* Patients who have slight deviation of the toe and a small exostosis will be made comfortable by wearing a properly fitted oxford-type shoe with a heel 1¼ or 1½ inches high, which has a strong, broad shank under the instep, a thick sole and a broad toe. These specifications are usually met by a nurses' duty shoe, a "saddle oxford" or a specially designed orthopedic shoe, and none of these correspond to a woman's idea of presentable footwear. However, unless the patient, who usually is a woman, can be persuaded that her present and future comfort depends upon her wearing such shoes except when she attends occasional social functions, there is no hope of giving her relief from her immediate symptoms or of preventing the development of greater deformity and more disabling symptoms. The shoe should be modified, depending upon the symptoms and degree of flattening of the metatarsal arch, by the insertion of a metatarsal pad or the addition of a meta-

tarsal bar ⅛ or ¼ inch thick to the sole of the shoe.

Patients who have more severe deformity of the great toe, a larger exostosis, a very broad, flat metatarsal arch with hammer toes, should wear a special orthopedic shoe designed for patients with bunions. This may require further modification by application of a ¼ inch metatarsal bar to the sole and a metatarsal pad inside the shoe, and for those who have severe hammer toes, the vamp of the shoe should be stretched or even cut out over the hammer toes and covered with a dome-shaped patch of leather.

Surgical measures should be reserved for the severe, disabling deformities and must be applied with good judgment and aftercare.

*Hammer Toe.* Hammer toe is a flexion deformity at the proximal interphalangeal joint of the second or occasionally the fifth toe, which may be congenital or acquired in association with arthritis, clawfoot and other foot disorders (Fig. 179). Disability is due to development of a painful callus on the dorsal aspect of the proximal phalangeal joint. Mild deformities can be treated by giving the toes sufficient room in the shoes and stockings and by persistent stretching of the affected joints. Severe deformities may require arthrodesis of the affected interphalangeal joint with resection to correct the deformity, and occasionally tendon section, lengthening and capsulotomy or excision of the middle phalanx of the involved digit. Amputation of the fifth toe is advisable in certain cases of persistent deformity; however, the second toe should never be amputated in an attempt to relieve this condition, as hallux valgus will invariably result, often disabling the patient to a greater degree than originally.

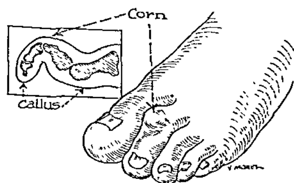


Figure 179. Hammer toe.

*Plantar Warts (Verruca Plantaris) (see also p. 109).* Plantar warts occur most commonly on the ball of the foot, seldom on the heel or instep. A true plantar wart has at its base a horny thick papilla which is distinct from the surrounding callus. These warts may be multiple. Diagnosis is aided by removal of the superficial layers of the callus with a sharp knife or blade.

*Treatment.* Some warts will disappear spontaneously. Use of a thick-soled shoe with a metatarsal pad or bar often relieves the pressure, gives comfort and prevents progressive enlargement. Cauterization is usually ineffective. Roentgen therapy, followed by use of corrective shoes, relieves most of the superficial, less chronic cases. However, overdosage or repeated treatments with roentgen rays will produce serious ulcers. Chronic ulcerating warts require wide excision with resection of the toe and corresponding metatarsal bone.

*Painful Heel.* Localized pain over the anterior part of the plantar surface of the heel occurs in stout people who stand and walk a great deal. Spurs of the os calcis may be found on roentgenologic examination. However, the pain is seldom due to the spur itself but rather to periostitis or plantar fasciitis at the attachment of the plantar aponeurosis to the os calcis. Therefore excision of the spur is not indicated. Overweight should be eliminated. Roentgen therapy occasionally helps. Elevation of the heel ¼ inch and use of a sponge rubber pad with a hole cut out beneath the painful area under the heel deserve a trial. Cozen[10] has reported good results after injections of a 1 per cent solution of procaine hydrochloride around the attachment of the plantar aponeurosis. In persistent cases with elevation of the blood uric acid, the use of colchicine and an appropriate diet is indicated.

*Retrocalcaneal and Achilles Tendon Bursitis.* The retrocalcaneal bursa, which lies between the Achilles tendon and the

tuberosity of the os calcis, may become painful, swollen and enlarged. Removal of pressure from the counter of the shoe, and injection of procaine or hydrocortisone are usually effective. Roentgen therapy is sometimes used. Bursitis of the Achilles tendon is characterized by pain near the insertion of the heel cord and frequently develops after wearing a new pair of shoes. Examination reveals tenderness over the heel cord just proximal to its insertion in the os calcis. Sometimes there is slight swelling, and crepitation may be detected as the foot is moved up and down.

*Treatment.* The counter of the shoe should be cut away and a felt pad ½ inch thick should be placed under the heel in the shoe. Occasionally an injection of a 2 per cent solution of procaine hydrochloride in the tender area is helpful.

***Ingrown Toenail.*** Ingrown toenails usually result from wearing narrow-toed shoes and short stockings or socks. Cutting back the corners of the nails also contributes. The toenails should be cut squarely across the ends, leaving the corners projecting slightly beyond the skin. The pressure may be relieved by wearing larger shoes and socks or stockings and by packing a wisp of cotton under the edge of the nail. Cozen[10] recommended painting the crevice between the nail and the skin with gentian violet and, as soon as this dries, applying several drops of 2 per cent solution of silver nitrate. The mixture of gentian violet and silver nitrate forms a coagulum which protects the tender painful skin from the edge of the nail. Dressings are not necessary.

If the soft tissue about the nail becomes infected, it should be treated by immersing the foot in hot water for 20 minutes, rest, elevation, and administration of penicillin. Severely ingrown nails which do not respond to conservative treatment may require surgical treatment. Such an operation is best done in the hospital under suitable anesthesia but can be done in the office after blocking the digital nerves on both sides at the base of the involved toe with a 2 per cent solution of procaine hydrochloride. Three cubic centimeters of solution is sufficient, but at least ten minutes is required for the block to become effective. A short diagonal incision is made proximally through the soft tissues at the base of the nail. About one-quarter of the width of the nail is excised throughout its entire length with scissors. A corresponding portion of the underlying nailbed should then be excised and the matrix curetted down to the periosteum to prevent recurrence. Petrolatum gauze should be inserted to the bottom of the wound, a snug dressing applied and the foot kept elevated for the first day or two. Codeine is usually required for rest. After two days the patient may be ambulatory in a shoe with the toe cut out.

***Osteochondroses about the Foot.*** Apophysitis of the calcaneus, osteochondrosis of the tarsonavicular bone (Köhler's disease) and osteochondrosis of the head of the second metatarsal (Freiberg's disease) are epiphyseal diseases occurring in adolescents and are characterized by circulatory disturbances and degenerative changes in the affected bone similar to those of coxa plana. These are painful conditions that can be confused with primary traumatic conditions, are frequently aggravated by trauma, and may be confused with chronic infectious lesions of the bones. For treatment, they require fixation in plaster and relief from weight bearing for varying periods of time.

*Apophysitis of the calcaneus* is characterized by tenderness and swelling at the back of the heel, pain on running and jumping, and occasionally a slight limp that may be bilateral and is aggravated by pressure of the shoes. Roentgenograms reveal fragmentation of the epiphysis on one or both sides. Treatment consists in raising the heels ¼ to ½ inch, removal of the stiff counter of the heel of the shoe and avoidance of vigorous exercise. The lesion heals spontaneously with time.

*Osteochondrosis of the tarsonavicular bone* is manifested by a limp and by pain, with tenderness and thickening of

the soft tissues over the navicular bone. It is generally unilateral. The pathologic picture is the same as that of the other osteochondroses. The diagnosis is confirmed by roentgenographic studies. Treatment of the mild case consists of limitation of activity and use of a strong shoe with a rigid shank, combined with a rubber or felt scaphoid pad. In severe cases, the foot should be immobilized in a plaster boot and the child required to use crutches. Symptoms usually subside in a few months, but the bone changes noted in serial roentgenograms may persist for several months after the clinical symptoms have subsided.

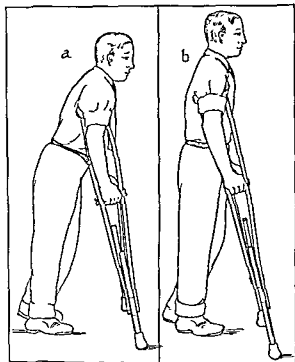



*Figure 180* Fitting of crutches. *a*, Crutches too short. Patient required to lean forward in walking and is carrying most of weight in axilla. *b*, Correct crutch length.

*Osteochondrosis of the metatarsal head* occurs most often in females between the ages of 10 and 15 years and affects the head of the second metatarsal. High-heeled shoes have frequently been mentioned as a causative factor. The outstanding symptom is a slight limp associated with localized pain under the second metatarsal head on weight bearing. Motion of the metatarsophalangeal joint is usually limited and painful. The characteristic roentgenographic appearance is flattening of the head of the second metatarsal, with irregular ossification. Treatment consists in restriction of activity and the use of low-heeled shoes with strong soles and a metatarsal bar. Occasionally, in chronic cases, excision of the head of the metatarsal may be necessary.

***Methods for Fitting Crutches.*** The following methods for determining the length of crutches have been recommended by Deaver and Brown:[12]

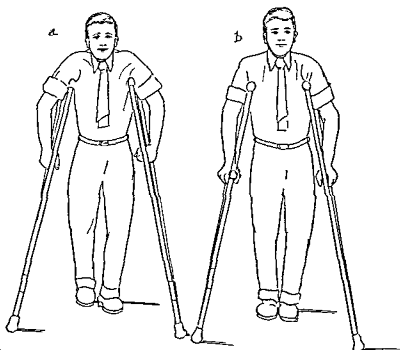



*Figure 181.* *a*, Hand holds too high. Elbows are flexed acutely. Weight is carried in axilla, not on hand hold. *b*, Correct height of hand hold. Elbows are flexed at 30°. Weight is on hands.

1. Take 77 per cent of the height of the patient.

2. Take the height of the patient and subtract 16 inches.

3. Measure the distance from the patient's axilla to the floor and add two inches to this length.

For height of the hand pieces, the patient's elbow should be bent to an angle of about 30 degrees from the vertical when he is standing erect with his hands strongly dorsiflexed and grasping the cross-pieces with his weight on the hands (Figs. 180, 181).

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Chapter 15

# Injuries of the Hand

*By Daniel C. Riordan*

The hand is the most useful and most vulnerable member of the human body. Because of its intricate anatomy, closely fitting joints and gliding surfaces, success in the surgical management of hand injuries depends upon surgical care skillfully carried out. This demands a sound knowledge of anatomy and function of the hand, a mastery of the techniques necessary for the repair of the damaged tissues and a knowledge of the necessary aftercare. The surgeon must understand the general principles underlying the care of hand wounds so that the initial treatment of the hand can be done properly when the occasion presents itself.

For details of the surgical anatomy of the hand the reader is referred to texts such as *Functional and Surgical Anatomy of the Hand* by Emanuel Kaplan (Philadelphia, J. B. Lippincott Co., 1953) and the *Clinical Symposia,* Vol. IX, No. 1, January-February, 1957, published by Ciba.

## INJURIES OF THE SKIN

Simple lacerations of the fingers or hand occur frequently. If they do not involve the deeper tissues, such as the tendons or nerves, they may be thoroughly cleansed and the wounds sutured, preferably under local anesthesia such as a digital nerve block or nerve block at the wrist. In the hand, the suture of choice is stainless steel wire monofilament No. 35 or No. 36. The proper technique with this wire produces good apposition of the subcutaneous tissues and the skin edges so that no buried sutures are necessary in the subcutaneous tissues. Incisions used should be those recommended by Bunnell (Fig. 182).

Crushing wounds in which the skin edges are badly traumatized should be thoroughly débrided and a very narrow margin of the wound edges should be excised if the skin is so traumatized that it is not viable. The hand, like the face, has an excellent blood supply. Excision of wound edges should always be minimal and should be done only when the edges are obviously nonviable.

All surgery of the hand should be done with the use of a pneumatic tourniquet, which can be used under local anesthesia, contrary to the popular opinion that it can be used only with general anesthesia. The blush of the skin produced by the release of the tourniquet after a 10- or 15-minute application is very useful in determining the viability

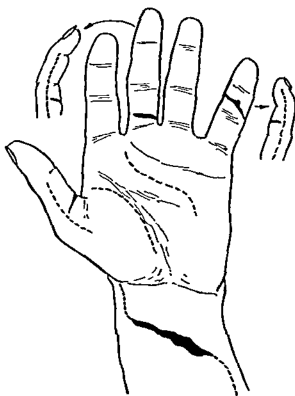


*Figure 182.* Incisions recommended by Bunnell and how they can be enlarged to repair wounds if necessary.

of badly traumatized skin. The use of the tourniquet for all surgery of the hand is strongly advocated, for, as Bunnell has so aptly said, "You cannot repair a watch in a bottle of ink."

When reversed flaps of skin have been raised by the injury and the blood supply is in question, all fat should be removed and the skin replaced. This should be watched carefully, and if it shows signs of necrosis it should be replaced with a skin graft at the earliest possible moment. It is extremely important that tendons, joint surfaces and nerves not be left exposed, as they have such poor blood supply that they will not survive without adequate cover. Split skin grafts or local flaps should be used to cover defects that exist. Wounds of the hand should not be left open, except for human bites. When seen early, human bites should have excision of wound edges and all traumatized tissue, and these wounds should be left open and irrigated every four hours with antibiotics. Injuries resulting in large areas of skin loss with denuded tendons, so that skin grafts cannot be applied, should have application of a primary abdominal flap to preserve the underlying tendons, joints and nerves. Thermal burns should be treated with pressure dressings and skin grafting as soon as the granulating surface is able to accept a split skin graft. Even if the open treatment is used on other parts of the body, pressure dressings and closed treatment should be used on the hand to prevent excessive swelling, which will result in marked fibrosis and stiffness of the joints.

### INJURIES OF TENDONS

Lacerations of extensor tendons may be repaired primarily at any level in the

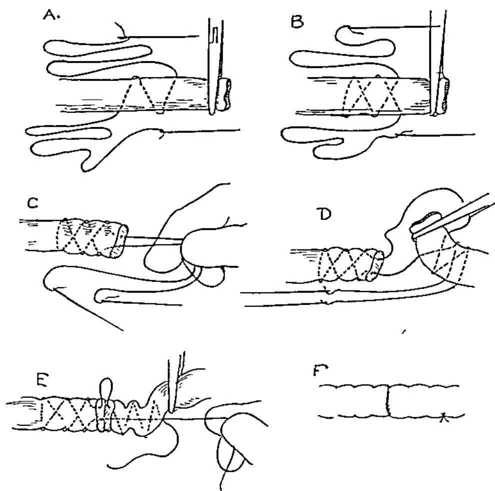



*Figure 183.* *A.* Start of Bunnell tendon to tendon stitch done with two needles *B.* Stitch completed in one half of tendon. *C.* Tendon and cut off and needle and suture brought out through cut end of tendon *D.* Stitch completed in other half of tendon with final pass of one needle bringing both ends of suture out on same side of tendon. *E.* Second end cut off and suture being tightened, drawing one stitch at a time. *F.* Completed suture

forearm, hand or fingers. A Bunnell type of stitch is used to approximate the severed tendon ends (Fig. 183). The preferred suture material at the present time is braided stainless steel wire, .05 mm. in diameter. This suture material is essentially without reaction; it may be left buried and usually causes no late difficulties. The only exception to the above is laceration of the tendon under or through the dorsal carpal ligament. In this case tendon ends may be sutured, but the overlying dorsal carpal ligament should be excised. This is to prevent adhesions of the severed tendon ends to the dorsal carpal ligament, which will result in limitation of motion. After repair of extensor tendons the hand should be immobilized with the wrist in approximately 30 to 40 degrees of dorsiflexion and the fingers in a position of about 160 degrees of extension at all joints. The fingers and wrist should never be forcefully or fully dorsiflexed and allowed to remain in this position for any length of time.

Flexor tendon injuries are much more complicated and as a general rule should not be considered minor injuries. Unless the operator is adequately experienced, the best treatment is a thorough débridement and closure of the skin, leaving the tendon laceration to be repaired at a later date by a more skilled operator. As a general rule, tendon lacerations above the level of the volar carpal ligament may be repaired at all depths, meaning that both flexor sublimis and flexor profundus tendons may be individually sutured and individual function expected. From the level of the volar carpal ligament to the distal flexion crease of the palm, only the profundus tendon should be repaired. The sublimis should be cut as far proximal and distal as possible and allowed to retract, but no attempt should be made to repair this tendon. There is room for only one tendon to function and glide in the hand after laceration of both tendons at this level. If both are repaired at the same level in this region of the hand they will adhere together and function of the sublimis tendon only will be obtained. If

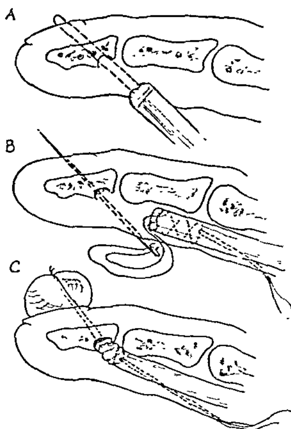



*Figure 184.* Bunnell pull-out stitch tendon to bone. *A.* Drill through distal phalanx at normal insertion of profundus tendon. *B.* Pull-out stitch placed in tendon and being passed through drill hole in finger. *C.* Pull-out stitch tied over bolster and pull out wire passed through soft tissues of finger proximally.

the laceration is from the level of the distal flexion crease of the palm down to within the distal centimeter of the profundus insertion, this tendon should not be repaired primarily except in young persons by an expert in cleanly incised wound. This region is commonly called "no man's land," a term originated by Bunnell. Adequate cleansing of the wound and closure of the wound followed by clean healing and delayed repair of the tendon or flexor tendon graft at six or eight weeks is preferred treatment in this region (Fig. 184), because of the very close fitting of the tendon sheath to the flexor tendons in the tunnels over the proximal and middle phalanges of the fingers. There is not room for repair of the tendons and the swelling following the injury to allow healing without adherence to surrounding structures. The gliding surfaces must be preserved in this region of the finger and the best form of treatment is to get clean

of badly traumatized skin. The use of the tourniquet for all surgery of the hand is strongly advocated, for, as Bunnell has so aptly said, "One cannot repair a watch in a bottle of ink."

When avulsed flaps of skin have been raised by the injury and the blood supply is in question, all of it should be removed and the skin replaced. This should be watched carefully, and if it shows signs of necrosis it should be replaced with a skin graft at the earliest possible moment. It is extremely important that tendons, joint surfaces and nerves not be left exposed, as they have such poor blood supply that they will not survive without adequate cover. Split skin grafts or local flaps should be used to cover defects that exist. Wounds of the hand should not be left open, except for human bites. When seen early, human bites should have excision of wound edges and all traumatized tissue, and these wounds should be left open and irrigated every four hours with antibiotics. Injuries resulting in large area of skin loss with denuded tendons, so that skin grafts cannot be applied, require application of a primary abdominal flap to preserve the underlying tendons, joints and nerves. Thermal burns should be treated with pressure dressings and skin grafting as soon as the granulating surface is able to accept a split skin graft. Even if the open treatment is used on other parts of the body, pressure dressings and closed treatment should be used on the hand to prevent excessive swelling which will result in marked fibrosis and stiffness of the joints.

## INJURIES OF TENDONS

Lacerations of extensor tendons can be repaired primarily at any level in the

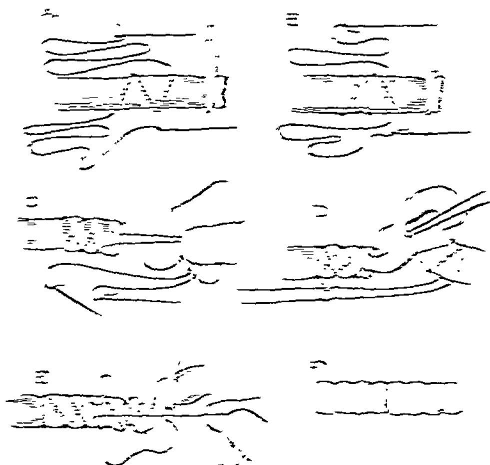


*Figure [illegible].* A. Start of Bunnell tendon to tendon suture done with two needles. B. Suture completed in one half of tendon. C. Tendon end cut off and needle and suture brought out through cut end of tendon. D. Suture completed in other half of tendon with final pass of one needle bringing both ends of suture out on same side of tendon. E. Second end cut off and suture being tightened, one stitch at a time. F. Completed suture.

the base usually undergo shortening and rotation. If seen early, restoration of length and alignment is easy and can best be maintained by Kirschner wire fixation. This is done by placing a Kirschner wire transversely into the adjacent stable metacarpal. If internal fixation is not used, it is usually necessary to maintain traction and flexion simultaneously—flexion of the metacarpophalangeal joint and the proximal interphalangeal joint in conjunction with dorsiflexion of the wrist. Skeletal traction is preferred, but occasionally pulp traction or skin traction will suffice. The latter two are not tolerated well and frequently result in complications.

Fractures in the midshaft or neck of the metacarpal usually result in angulation of the distal fragment, the metacarpal head being prominent in the palm. These may be reduced by flexing the finger at the metacarpophalangeal joint and exerting pressure dorsally on the proximal phalanx, maintaining pressure on the proximal fragment at the same time (Fig. 185). This position may

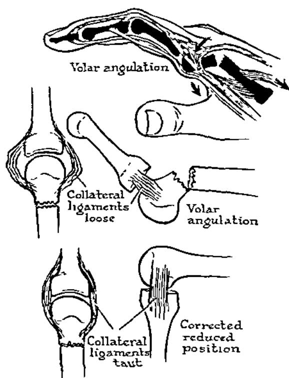



*Figure 185.* Volar angulation of distal fragment, relationship of collateral ligaments in deformed position seen at top. Bottom view shows corrected reduced position and taut collateral ligaments.

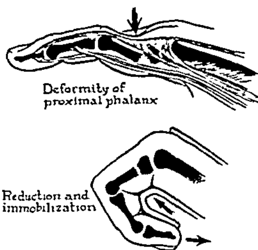



*Figure 186.* Top, fracture of proximal phalanx with usual deformity. Bottom, reduced fracture and position of immobilization.

be maintained by a well padded plaster splint or cast. This type of treatment should not be used in elderly persons because of the danger of obtaining stiff joints from the position of acute flexion of all the joints involved. If reduction cannot be maintained easily, internal fixation with a Kirschner wire placed transversely into a stable adjacent metacarpal is the treatment of choice. If internal fixation is used, frequently no immobilization is utilized. The fixation should be continued for two or three weeks, depending upon the clinical signs of union. After this period, motion can be started provided there is no other contraindication to motion.

Fractures of the proximal phalanx usually angulate dorsally. They are reduced by flexing all joints supporting the volar surface. In oblique fractures skeletal traction may be necessary, maintaining the finger in the flexed position (Fig. 186).

Fractures of the middle phalanx may produce two types of deformity. If the fracture is proximal to the insertion of the sublimis tendon, the distal fragment is brought into flexion by the sublimis tendon. The reduction is done by reversing the deformity and then flexing the metacarpophalangeal joint and proximal interphalangeal joint to release the pull of the sublimis tendon; the distal fragment will be dorsiflexed by the extensor mechanism and the proximal fragment flexed by the sublimis tendon.

healing of the wound by simple suture of the skin and the performance of a flexor tendon graft at six or eight weeks. Lacerations within the distal 1 to 1.5 cm. of profundus insertion may be treated by excision of the short distal fragment and insertion of the proximal fragment into the distal phalanx.

### INJURIES OF NERVES

Most experienced hand surgeons feel that a delayed nerve suture will give better return of sensation or motor power in most instances. This does not mean that nerves should not be sutured primarily, but since one is unable to tell at the time of injury how far back the nerve axons have been damaged, the nerve ends should be approximated only for the purpose of preventing retraction. In some cases, when a nerve has been cleanly divided by a sharp instrument and has not been traumatized at a more proximal or distal level, a definitive careful primary suture of the nerve may be done. Suturing should be with the finest 6-0 silk on atraumatic needles using interrupted sutures in the nerve sheath. An adequate nerve suture requires very careful technique and close attention to fine detail. It serves no useful purpose to put a suture through a nerve end and to allow the nerve end to retract. Except in a wound such as a human bite, which should be left open, the nerve ends should always be approximated with a 6-0 suture to prevent retraction. At six or eight weeks a re-exploration of the wound and good approximation of the nerve ends after excision of the neuroma and glioma can be done much more easily than on a primary laceration of the nerve. During this interval the nerve sheath has thickened somewhat and sutures are more easily placed in it, so that a better approximation of the sheath and axons can be obtained. Nerve sutures may be done at all levels of the forearm and hand, out to the distal flexion crease of the fingers. At this point the nerve becomes so small that it is almost technically impossible to suture adequately.

### INJURIES OF BONE

*Dislocations.* Dislocation of the base of the metacarpals is a common injury and is easily missed. X-rays should be carefully examined for this deformity. Frequently, the anterior half of the base of the metacarpal is fractured, making reduction difficult to maintain. Open reduction is usually not necessary, but internal fixation is frequently necessary. This is best obtained by the use of Kirschner wires placed transversely into the adjacent metacarpals to maintain the reduction. Occasionally, a Kirschner wire can be placed obliquely into the carpal bones to maintain reduction Three weeks' immobilization is usually adequate, but occasionally five weeks will be necessary.

Dislocation of the metacarpophalangeal joint is serious and requires immediate reduction. Frequently, this can be done by closed methods, but if reduction is not successful immediately, an open reduction must be done. Dislocation of the metacarpophalangeal joint usually means that the strong collateral ligaments have been torn. Therefore, the postreduction immobilization should be in the position of flexion to allow these ligaments to heal without undergoing shortening. Three weeks' immobilization is considered sufficient, and after this, motion should be started and should be carried out until a full range of motion has been obtained.

Dislocation of the interphalangeal joint is common. In most instances, reduction can be achieved without the use of anesthesia. After reduction has been obtained, the joint should be tested for lateral stability. If the joint is stable, no immobilization is needed. If the joint is unstable laterally, it should be immobilized in a position of flexion for seven to ten days, and then motion should be started. Early motion is desirable in the interphalangeal joints because of the tightness of the fit of these joints into one another. If immobilization is prolonged, a stiff joint will result.

*Fractures.* Metacarpal fractures near

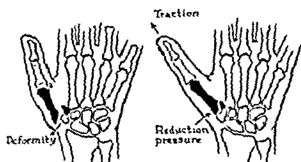



*Figure 189.* Left, fracture and deformity produced. Right, reduction. Arrow shows traction in longitudinal axis and pressure over the base of metacarpal to maintain reduction.

weeks. If anatomic reduction cannot be obtained on the first try by closed means, an open reduction should be done immediately. This should not be delayed. If open reduction is done, the reduction is maintained by the use of Kirschner wires across the fragment or by a single wire loop passing through small drill holes placed through the two fragments. After internal fixation, immobilization is necessary only until skin healing has occurred, which will be between two and three weeks. Motion can then be started and usually returns to normal quickly. If reduction has not been successful primarily, traumatic arthritis usually results rather rapidly and causes pain on all motion of the thumb. After this has occurred a late reduction is usually impossible, and a fusion of the carpometacarpal joint is necessary. This results in some limitation of motion of the thumb, but gives pain-free motion and leaves a satisfactorily functional thumb.

INFECTIONS

Paronychia may be treated by simple incision if it is confined to one side of a finger (Fig. 190). If the paronychia has run around the base of the nail to both sides of the finger, it is best treated by excision of the base of the finger nail. Pulp infection of the terminal phalanx of the finger is usually confined by the trabeculae of the fibrous tissue, which fix the dermis to the underlying phalanx or tendon sheath. Pain is a prominent symptom and comes on quickly because of the tight fixation of the dermis to the bone, which prevents swelling. The condition should be treated promptly by lateral incision (Fig. 191). A tourniquet should be used so that adequate visualization of the abscess can be obtained. All of the septa should be cut in the involved part. If this type of infection is seen quite early and is localized, an incision may be made over the area on the volar aspect where it is pointing. Usually, however, a lateral incision is indicated. If the infection has been more severe and involves the bone of the distal phalanx, the lateral incision should be carried farther around the tip of the finger, and in severe cases a fishmouth type of incision can be used for complete

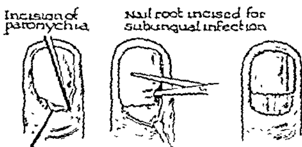



*Figure 190* Left, simple incision of unilateral paronychia. Center and right, excision of nail for run around paronychia.

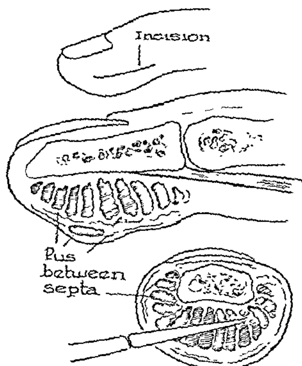



*Figure 191.* Pulp space infection, distal phalanx. Top, position of incision in midlateral area. Center, abscess with pus between septa Bottom, position of knife as seen in cross section cutting septa near the phalanx

Reduction of this fracture is done by flexing the distal fragment and maintaining flexion of all the joints, usually by a splint. This fracture heals more rapidly than those of the proximal phalanx, and three weeks' immobilization is usually sufficient. Occasionally, longer immobilization will be necessary (Fig. 187).

Fractures extending into the interphalangeal joints usually result in shortening and a lateral deformity. All such fractures should be treated by continuous traction, which is best done by skeletal means. Traction must be maintained until healing has occurred, otherwise deformity will recur. This immobilization should be continued for at least three weeks, and then motion started.

Fractures of the distal phalanx usually are not serious and do not require any more than simple immobilization for three weeks until swelling and pain have disappeared.

The most important injury to the distal phalanx is avulsion of the insertion of the extensor tendon. This results in the common baseball or mallet finger and inability to extend the tip of the finger. Reduction is obtained by relaxing the pull of the interossei and lumbrical muscles, since they are the active extensors of the interphalangeal joints of the finger (Fig. 188). Relaxation of this extensor mechanism is secured by

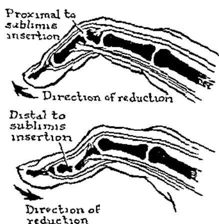



*Figure 187.* Top, fracture proximal to sublimis insertion with deformity produced. Reduction is obtained by moving distal fragment in [illegible] direction of arrow.

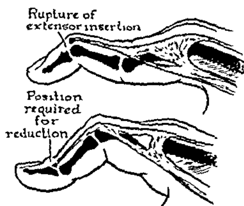



*Figure 188.* Top, rupture of extensor insertion and deformity produced. Bottom, position required for reduction.

flexing the metacarpophalangeal joint, flexing the proximal interphalangeal joint and hyperextending the distal interphalangeal joint. Immobilization is best done with a small plaster splint and gauze bandage. The gauze bandage is made to adhere to the skin on the dorsum of the finger by the use of tincture of benzoin or Ace adherent. This fracture should be checked with an x-ray, and if reduction is not nearly perfect, an open reduction is indicated. If open reduction is done, the fragment can usually be excised and the extensor tendon reinserted with a Bunnell type of pull-out suture.

***Bennett's Fracture.*** This fracture dislocation of the carpometacarpal joint of the thumb is the most disabling fracture of the hand. The fracture involves a part of the articular surface of the joint and results in a dislocation, partial or complete, of the base of the first metacarpal on the greater multangular. Anatomic replacement of the fragment is essential in order to prevent the development of traumatic arthritis and a painful hand (Fig. 189). This can be done by closed means by using a well fitting plaster cast, maintaining pressure against the base of the metacarpal and maintaining traction in the longitudinal axis in the thumb. Occasionally, skin traction will suffice, but this is not advised. Traction is best obtained by skeletal means. The traction and the pressure against the base of the first metacarpal must be maintained continuously until healing has occurred, which will be at least three

to the dorsal surface of the hand, most frequently points to the dorsum of the hand and should be drained through a longitudinal dorsal incision in the interspace and a volar curved incision skirting the edges of the metacarpal heads. Infections on the dorsal aspect of the hand and fingers should be drained through a curving incision, one arm of which is proximal to the abscess to prevent its being carried proximally into the loose tissue spaces. All infections requiring incision should be drained and irrigated with antibiotics, and systemic antibiotics should be used as well.

### GANGLION

A ganglion is a small, smooth cystic structure which contains thick, clear mucinous fluid and usually arises from a tendon sheath or joint capsule. It may have a single cavity or may be multilocular. The most common site for ganglia is the dorsal aspect of the wrist joint, but they may also be present over the interphalangeal joints. The most common site in the interphalangeal joints is the distal joint in patients with hypertrophic arthritis. Ganglia may also arise on the flexor side of the hand, are most commonly associated with the vaginal tendon sheath and are situated over the proximal phalanx. These are usually quite firm and relatively mobile. Such a ganglion should be excised and when it is removed, a small bit of the flexor tendon sheath should be excised; this is thought to be a degenerative process, and if the sheath is not excised in this area the ganglion may recur. Small early cysts may sometimes disappear when injected with cortisone or one of its derivatives. The best treatment, however, is surgical removal which includes removal of the joint capsule or tendon sheath at the pedicle or place of origin of the ganglion. Aftertreatment consists of three weeks of immobilization with the wrist in dorsiflexion, followed by appropriate physical therapy.

### STENOSING TENOSYNOVITIS

Stenosis of a tendon sheath is known to occur in several locations on both upper and lower extremities. On the flexor tendons it occurs over the metacarpophalangeal joint and may involve the thumb or the other fingers. On the thumb the cause may be the sliding of the tendon over enlarged sesamoid bones. Incision or excision of the annular ligament at the metacarpophalangeal joint is curative. On the index, long, ring and little fingers stenosing tenosynovitis is associated with constriction of the proximal part of the vaginal sheath, and in late cases may be associated with marked nodular swelling of the flexor tendons and sometimes even severe fraying of the sublimis tendon. Here again, the tendon sheath may be incised or a part of the sheath excised in its proximal one-third, if the swelling of the tendon is severe. The loose tendon ends from the frayed portion should be excised by stripping these tendon pieces back proximally and cutting them off proximal to the region of constriction. Stenosis at the radial styloid, termed de Quervain's disease, is treated by surgical incision or excision of the annular ligament. Early cases and mild cases of this stenosing tenosynovitis are sometimes completely relieved by injection of the tendon sheath with cortisone or one of its derivatives. If there is any swelling of the tendon or if the constriction of the ligament is severe, the condition will usually recur after the injection and will require surgical treatment.

### AMPUTATIONS

In most cases of injuries to the fingers requiring partial amputation, the best closure is obtained by excising sufficient bone to allow a volar flap of skin to cover the end of the amputation stump. The nerve ends should be cut at least ½ inch proximal to the amputation site. This is done by applying traction on the nerve and cutting it off as far proximal as possible. Occasionally more skin is not available for closure of the end of the stump; in this case a lateral or dorsal flap of skin may be used. In most cases of laborers who use the hands under difficult situations this type of amputation is necessary. Occasionally,

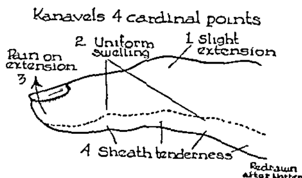



*Figure 192* Tendon sheath infection showing Kanavel's four cardinal points characteristic of tendon sheath infection.

drainage of the abscess and removal of the necrotic bone The wound is not closed in this instance, but is laid in apposition with a drain from side to side.

Pulp infection may also involve the middle phalanx or proximal phalanx. In this situation a lateral incision is made and adequate drainage of the space is provided.

Tendon sheath infection may result since there is only a very thin membrane separating the flexor tendon from the subcutaneous tissues. If the infection enters the tendon sheath of the index, long or ring finger it may not extend into the palm, since the tendon sheaths of these three fingers stop at the level of the metacarpal head (Fig. 192). The tendon sheath of the thumb connects with the radial bursa and may carry the infection clear above the wrist. The tendon sheath of the little finger connects with the ulnar bursa and may carry the infection into the palm and above the wrist. The palm itself has two spaces known as the thenar space or bursa and the midpalmar space or bursa (Fig. 193). The septum from the palmar fascia to the third metacarpal divides the hand into these two compartments. This midpalmar compartment is situated deep to the flexor tendons but superficial to the interossei.

A collar button abscess may involve the loose fascial spaces in the region of the metacarpal heads between the fingers. The abscess extends from the volar

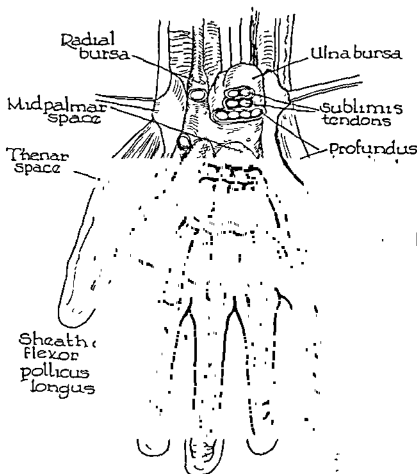



*Figure 193.* Anatomy of flexor tendons at level of wrist, palm, and fingers. Relation of flexor tendon sheath of thumb and other fingers, and the palmar spaces.

*Part IV*

# Alimentary Tract



*Figure 194.* Universal splint of Mason and Allen can be used for either left or right hand.

a person may want as much length of the finger as possible because of some other type of occupation; in such cases if the bone is covered with sufficient subcutaneous fat a split skin graft or Wolff graft may be applied. When only the pulp of the tip of the index or long finger is missing, a thenar flap may be used to cover the tip of the finger. This should be done only with young persons, however, as it may lead to joint stiffness if performed on older patients. When amputation is necessary near the base of a finger, the base of the proximal phalanx should be left if possible. If this must be removed, too, the metacarpal head should be allowed to remain, which will help to prevent the adjacent fingers from wandering into the defect. If a metacarpal head has to be removed on one of the two central fingers, at a later date a resection of the remaining metacarpal and transposition of the index or little finger into the defect can be done. On the thumb as much length as possible should be retained, but here again in the working man the best amputation stump is one which is covered with an adequate volar flap of skin.

### POSTOPERATIVE CARE

Except for very small lacerations not involving deeper tissues, sutures should be left in hand wounds from two to three weeks. Immobilization of lacerated tendons for either flexors or extensors should be for a three weeks' period following the repair. It should be remembered that a tendon suture is not strong until six weeks has elapsed, so that no forceful manipulation or forceful motor activity on the part of the patient should be allowed until this period of time has elapsed. Immobilization should always be in the functional position if this is at all possible. This may be done by means of a pressure dressing and plaster splints, or by using a ready-made splint such as the Mason Allen Universal splint. Unless there is evidence of infection, one usually need not disturb the postoperative dressing until it is time to remove the sutures, which in most instances are left in for three weeks. Graded exercises after removal of dressings are done as it usually requires a period of several weeks or longer to regain motion in fingers after injuries of more than trivial degree (Fig. 194).



*Figure 196.* A. Eight-year-old child with ankyloglossia. *B.* Result obtained in patient shown in *A* by technique described in Figure 195.

pulled forward and the wound in the posterior part of the tongue easily exposed and satisfactorily treated.

Because of the danger of contamination from organisms within the mouth and in order to control hemostasis, it is essential to repair injuries of the lip and tongue as quickly as possible. Local infiltration with a 0.5 per cent or 1 per cent solution of procaine satisfactorily relieves all pain. However, a 2 per cent solution of Xylocaine (plain or with epinephrine 1:100,000) gives anesthesia that is more profound and of longer duration, and better hemostasis. If there is active bleeding, this should be controlled by grasping the bleeding vessel and ligating it, after which the mucous membrane should be carefully approximated with interrupted nonabsorbable sutures, such as cotton, or absorbable sutures. Injuries that penetrate through the cutaneous surface should be carefully cleansed with soap and water or a satisfactory detergent, such as ether or pHisoderm, and after injection of a local analgesic agent the wound edges should be excised, if they are ragged, and approximated with interrupted nonabsorbable sutures. No dressing need be applied to the mucous membrane surface, but a small collodion dressing should be applied over the cutaneous wound. Because of the danger of contamination with organisms in the mouth, such as the Vincent's spirochete, which is an anaerobe, an oxidizing mouthwash, such as sodium perborate solution, should be used for several days, and 400,000 units of penicillin should be administered daily for 3 to 4 days. In the presence of poor oral hygiene, a buffered sodium perborate (sodium peroxyborate monohydrated buffered with anhydrous sodium bitartrate) should be prescribed.

### GLOSSODYNIA

Glossodynia, although only a symptom, must be considered because it frequently is disabling. Patients are concerned with the discomfort and also because of the fear of a possible underlying neoplastic disease. Obviously, if there is any inflammatory or irritative reaction of the tongue which might account for the pain, this should be corrected and relief of symptoms will be prompt. Rarely glossodynia is caused by true neuralgia of the lingual nerve, in which instance the involved side of the tongue is extremely hypersensitive. A frequent cause of glossodynia in women who have undergone the menopause, many with anxiety tensions, is decreased salivary flow with resulting xerostomia. Glossodynia may result from temporomandibular arthritis as a reflex pain through the capsular fibers of the auriculotemporal nerve to the lingual nerve branches of the trigeminal nerve. In temporomandibular arthritis pain stimuli occur because of inflammation of the joint capsule due to dysfunction. Correction of the temporomandibular dysfunction by a competent dentist or an oral surgeon may relieve the glossodynia.

### DEFICIENCY GLOSSITIS

Changes in the tongue resulting from dietary deficiencies and blood dyscrasias

*Chapter 16*

# Diseases of the Mouth

*By Alton Ochsner*

## ANKYLOGLOSSIA

Of the congenital anomalies of the mouth that can be treated by the physician in his office and therefore can be considered as minor surgery, "tongue-tie," or ankyloglossia, is the only one that will be discussed here Because of shortening of the frenulum, there is interference with normal mobility of the tongue and, as a result there is likelihood of an infant's having difficulty in nursing. If the condition is allowed to persist, some speech difficulty may result. Generally the condition is not of much consequence even though there may be some slight interference with speech because usually, as the child becomes older, the mobility of the tongue increases. If the condition is severe, wedge resection of the lingual frenulum with the use of a local anesthetic followed by longitudinal closure of the wound with interrupted sutures freely mobilizes the tongue (Figs. 195, 196).

## INJURIES

Injuries of the lip can be caused by falling on the face, by blows on the face or by sharp objects. Injuries to the lip, particularly the lower lip, and the tongue can occur as a result of perforation by the teeth. Such injuries frequently go all the way through the lip, penetrating both the mucous membrane side and the cutaneous side.

Because of the extreme vascularity of the lips, cheeks and tongue, hemorrhage is profuse. It is readily controlled immediately by compression. In injuries involving any part of the tongue back of the anterior portion, the wound is best exposed by injecting a local analgesic agent, such as procaine, into the tip of the tongue and passing a suture through the tip of the tongue to be used for retraction. In this way the tongue can be

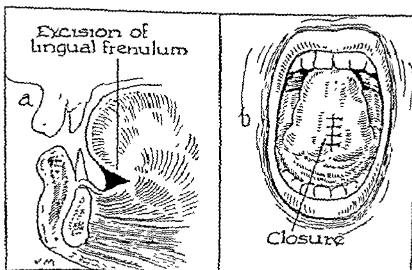



*Figure 195.* Technique of treating ankyloglossia. *a.* With use of a local anesthetic, a wedge of the frenulum is excised. *b.* Longitudinal closure is accomplished with interrupted sutures.

volves the lips and corners of the mouth is cheilosis (la perlèche). This consists of irritation and cracking of the lips and angles of the mouth, which are preceded by whitish discoloration (Fig. 197*b*). It is the result of vitamin deficiency, generally vitamin B complex. Although cheilosis has been considered the result of riboflavin deficiency, it also responds favorably when nicotinic acid and pyrodoxine are administered. The lesion is of no significance except that it is an expression and indication of vitamin and nutritional deficiencies which require correction.

### GEOGRAPHIC TONGUE

Geographic tongue is a peculiar condition of unknown etiology. It occurs most frequently in children and in young women with nervous temperament, usually during menstruation. The peculiar configuration is caused by areas of reddish color which are depapillated and are contrasted with the adjacent normally papillated mucosa. The margins, which are reddish yellow, are well defined. Other characteristics of geographic tongue are the variation in the size and shape of the depapillated areas from day to day and the ability of the involved areas to become repapillated spontaneously without therapy.

The condition produces few symptoms and is frequently detected accidentally. Occasionally the patient complains of slight pain or itching, which may be entirely psychic. Geographic tongue is a self-limited condition and requires no therapy aside from reassuring the patient that the lesion is of no consequence and is neither malignant nor premalignant.

### BLACK OR HAIRY TONGUE

Black or hairy tongue is a condition affecting the dorsum of the tongue. It consists of keratinizing extensions of the filiform papillae[3] which cause a brown or blackish discoloration and give the tongue the appearance of being covered with hair. It is now considered primarily a "filth disease" resulting from accumulation of food debris in the crypts of the filiform and fungiform papillae. It occurs most frequently in pipe smokers. Treatment consists in discontinuance of smoking, use of peroxide as a mouth wash and brushing the surface of the tongue with a tooth brush and tooth paste three times a day.

### STOMATITIS

Burket[4] distinguished three types of stomatitis: (1) aphthous stomatitis, (2) acute herpetic stomatitis and (3) recurrent herpetic stomatitis.

*Aphthous stomatitis (herpetic stomatitis)* is a herpes simplex virus infection consisting of yellowish papulovesicular lesions which may be discrete or occur in groups. Ulceration occurs early. Although the lesions can occur in any portion of the buccal cavity, they are found most often on the edges of the tongue. Frequently they appear just preceding menstruation. One crop may follow another, but usually not until the preceding one has healed.

The ulcer is preceded by a vesicle which ruptures early. The symptoms are usually mild and consist of pain and burning in the region of the ulcer, particularly when the ulcer is touched. The course of the condition is usually self limited, lasting 10 to 12 days, but the symptoms can be alleviated by use of a mild, superficially acting medicament (Negaton) which precipitates the surface protein of the ulcer. Acid in highly seasoned foods should be avoided. Good oral hygiene and use of an astringent, antiseptic mouth wash are beneficial. Use of strong caustics is contraindicated because of the likelihood of additional destruction of the mucous membrane and deepening of the ulcer.

*Recurrent herpetic stomatitis* is a papulo-ulcerative condition involving the mucous membrane of the lips, cheeks and tongue. It is frequently seen in children and infants, in whom the gingivae become swollen early in the course of the disease but subside spontaneously. In some patients the condition persists into adult life. It occurs *predominantly in* females and may be precipitated by menstruation, pregnancy, vitamin B deficiency, mild trauma to the mouth and



*Figure 197.* *a*, Deficiency glossitis consisting of papillary hypertrophy (photograph by courtesy of Dr Grace Goldsmith). *b*, Cracking of angles of mouth (cheilosis) resulting from vitamin deficiency (photograph by courtesy of Dr Grace Goldsmith). *c*, Retention cyst of lower lip. *d*, Ranula retention cyst of sublingual glands

are common. According to Afonsky[1] this condition "occurs in vitamin B complex deficiency, macrocytic hyperchromic and microcytic hypochromic anemias, and gastrointestinal disorders. Although it accompanies many apparently unrelated conditions, its etiology is basically the same in every case: a derangement in cellular metabolism. The deficiency glossitis should be regarded as a sign of great diagnostic significance since it is an indication of the profound pathology of a deficiency state." The changes in deficiency glossitis consist of papillary hypertrophy (Fig. 197 *a*) in early stages followed by atrophy with the production of the "smooth tongue." The tongue is frequently excessively red, even scarlet red. In riboflavin deficiency it is magenta. DePalma[2] classified diseases of the tongue on the basis of changes in the papillae. The dorsum of the tongue contains two types of papillae: the fungiform, which are located principally at the sides and apex, and the filiform, which are located on the anterior two-thirds of the tongue. The desquamated tongue, which is likely to be red, swollen and coated, is associated with great decrease in the filiform papillae. This is relatively easily treated. The atrophic tongue, which is a smooth tongue, is associated with absence of filiform papillae and pronounced reduction in fungiform papillae. DePalma also described cross patching of the tongue, which is the result of extreme thinning of the mucosa, permitting visualization of the underlying fibromuscular network and also longitudinal ridging caused by folds in the mucosa. Deficiency glossitis is to be differentiated from geographic tongue by the stability of the lesion and the lack of rapid changes in the papillae which characterize geographic tongue.

Treatment of deficiency glossitis consists in correction of the underlying disorder in gastrointestinal disease, pernicious anemia, sprue, etc., and specific therapy with vitamin $B_{12}$ and B complex, niacinamide, riboflavin and folic acid.

Another deficiency disease that in-

but are likely to occur on the lateral borders of the tongue. If present for 10 days or longer with no evidence of healing, they should be biopsied because of the danger of mistaking a simple ulcer for some of the other lesions.

### LICHEN PLANUS

Lichen planus is a disease, usually chronic in nature, which may affect the oral mucous membrane and the skin. In many instances, both the skin and the oral mucous membrane are affected simultaneously. On the other hand, at times only the oral mucosa is involved. Usually the lips, tongue and buccal mucosa are involved and more rarely the palate and gingivae. Lichen planus occurs primarily in women between 35 and 50 years of age. The lesion consists of hyperkeratotic nodules associated with severe inflammation, the inflammatory reaction being greatest at the periphery of the lesion. Sometimes involvement assumes a lacelike configuration (Fig. 199).

Because of the white discoloration and the hyperkeratosis, the lesion is likely to be confused with leukoplakia, necessitating biopsy for diagnosis. Lichen planus, however, has more frequent spontaneous remissions and often is associated with cutaneous involvement. According to Burket,[4] the bluish white color is of diagnostic importance in differentiating it from leukoplakia. Although the condition is generally thought to be relatively benign and of no significance concerning development of malignant change, Marshall[6] believed that because of the increasing number of carcinomas occurring in persons who have had lichen planus, possibly there is a causal relationship between the two conditions. Water soluble vitamin A therapy has been reported to be of value.



*Figure 199.* Lichen planus of buccal mucosa on the left side.

### ALVEOLAR ABSCESS OR GUM BOIL

A periapical abscess in the alveolus resulting from necrotic dental pulp may point on the buccal mucosa opposite the involved tooth with production of a gum boil. Before extension to the buccal mucosa, acute suppurative pulpitis occurs, causing severe pain and localized osteitis at the apex of the root of the tooth.

At this stage, drainage of the pulpal abscess by drilling a hole into the pulp chamber of the tooth by a dentist will frequently relieve symptoms. Extraction

*Fig. 200*

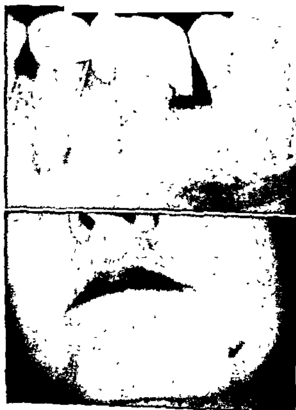


*Fig. 201*

*Figure 200.* Roentgenogram showing periapical abscess that had ruptured to the external surface of the face as shown in Figure 201.

*Figure 201.* External fistula of lateral aspect of mandible, after rupture of periapical abscess, illustrated roentgenographically in Figure 200.

certain sensitivities to foods (English walnuts, fruit juice and chocolate). Usually the lesions are multiple and quite painful; they may interfere with eating and thus cause nutritional disturbances. Occasionally the condition is accompanied by *fever and lymphadenopathy.*

The disease usually runs a self-limited course, provided secondary infection does not occur. In order to prevent infection, a mouthwash with sodium perborate, which is an oxidizing agent, should be used and penicillin should be administered systemically. Aureomycin has been advocated, but although this drug is valuable in controlling many infections, it must be emphasized that its administration can cause ulcerative lesions of the digestive tract, including the buccal cavity. By some the condition is considered due to riboflavin deficiency. Because of the possible role which vitamin deficiency may play, it is desirable to give large doses of vitamin B complex and vitamin C. After subsidence of the manifestations, repeated vaccinations with smallpox virus 8 to 10 times at 7 to 10 day intervals have been advocated. Recently Strean[5] advocated use of gamma globulin in resistant cases. He has treated successfully 50 patients with daily dosages of from 3 to 10 cc.

### RETENTION CYSTS

Small retention cysts may involve the mucous glands of the mouth, particularly those of the mucous membrane lining the cheeks, lips and tongue (Fig. 197*c*). These are mucoceles and are due to plugging of the ducts of the mucous glands. A small, nontender mass which appears to be filled with fluid is seen. It produces no symptoms and is usually detected accidentally by the patient. Treatment consists in extirpation, either with or without local analgesia. Generally, the lesion is so small that approximation of the epithelial surfaces is not necessary, healing by secondary intention being sufficient.

Other retention cysts that occur in the mouth are those resulting from blockage of the sublingual ducts. This produces cystic swelling of the floor of the mouth

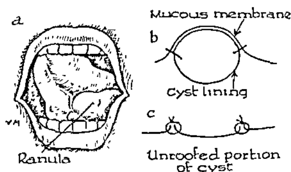



*Figure 198.* Technique of treating large submucous ranula. *b.* With use of local analgesia, the overlying mucosa and roof of the cyst are excised *c.* The edges of the buccal mucosa and the lining of the floor of the ranula are sutured with interrupted sutures.

on either side of the frenulum and is at times described as a ranula (Fig. 197*d*). The symptoms are those of swelling. There is usually no associated inflammation, and the patient is unaware of it aside from the tumefaction. Because these lesions vary considerably in size, the type of therapy varies. One can confirm the diagnosis by aspirating the contents with a fine needle. Ranulas may be satisfactorily treated by excising the overlying buccal mucosa and the superficial wall of the cyst (unroofing the cyst) followed by suture of the epithelial lining of the cyst to the mucous membrane of the floor of the mouth. The remaining cyst epithelium becomes the oral epithelium of the floor of the mouth (Fig. 198).

### INFLAMMATORY LESIONS OF THE BUCCAL CAVITY

As a result of trauma, usually caused by ill-fitting dentures or injury resulting from a jagged tooth, a granuloma with superficial ulceration can occur. Because of the inflammatory reaction, the ulcer is usually painful although not excessively so. The ulcers are of relatively little significance if the originating factor responsible for their development is corrected. On the other hand, because of the possibility that a simple ulcer might be confused with more serious ulcers, one must always determine whether some other underlying condition is present, such as tuberculosis, syphilis or cancer. Simple ulcers may be found anywhere,

sion because in more than 2000 cases of cancer of the tongue observed in the Memorial Hospital, in no instance was the lesion located in the midline of the tongue immediately anterior to the circumvallate papillae. Histologically hypertrophy and hyperplasia of the superficial layers of the mucous membrane with considerable lymphocytic infiltration of the base may be seen. There is no evidence of invasion of the deeper layers. Treatment consists in reassurance of the patient. If the patient is concerned about it, it can be removed with use of local analgesia, as an office procedure.

### GINGIVITIS OF PREGNANCY

Not infrequently associated with pregnancy is an inflammatory process involving the gingivae. Ziskin and associates,[9] in a series of 416 pregnant women, found evidence of gingivitis in 38 per cent. Of those with gingivitis, 70 per cent had the hypertrophic form, 41 per cent had "raspberry gum," 1.8 per cent had pregnancy tumors, and 13.2 per cent had a combination of the various types. The lesion varies considerably from a slight swelling of the gingiva to actual tumefaction which extends out between the teeth. The minimal changes are swelling and increase in vascularity of the marginal gingivae and intradental papillae. Although most noticeable during pregnancy, they occasionally occur during menstruation. During pregnancy, they are most likely to occur during or shortly after the third month. The gums have increased tendency to bleed, especially after brushing of the teeth. In more advanced forms the gum, especially in the anterior portions, becomes extremely hyperemic and has been designated as "raspberry red gum."

Pregnancy tumors, which are an exaggerated form of gingival hypertrophy, usually occur in the anterior portion of the mouth and develop from the intradental papillae. Because of their vascularity they are likely to bleed, and when they attain any size are likely to interfere with mastication. Because of their location they may be confused with epulis, which is a benign tumor arising from the dental periosteum. The tumor, which is attached by a pedicle to the interdental papillae, is cyanotic and has a bright red border.

Usually gingival hypertrophy during pregnancy is of no significance and requires no therapy aside from meticulous oral hygiene in order to prevent secondary infection, especially with Vincent's organisms. Ziskin and associates[9] showed that estrogens in large doses cause hyperkeratinization in the surface of the alveolar gingivae and regression of the gingivitis. However, in patients with pregnancy tumor, it may be necessary to remove the tumor because of interference with mastication and a tendency toward hemorrhage. Generally, the condition subsides after parturition, but if it continues for several months, it should be removed, because it is likely to recur in subsequent pregnancies.

### BENIGN TUMORS

Relatively frequent tumors of the buccal cavity involving primarily the cheek or lips, but sometimes involving the tongue, are fibromas (Fig. 202*a*). They are probably caused by irritation, such as biting of the mucous membrane, with hypertrophy of the area as a result of the trauma. They have no significance except that they frequently are injured during mastication and cause considerable annoyance. They are not premalignant lesions and, therefore, need not be removed because of this. On the other hand, because they do interfere with mastication and are a cause of concern to the patient, they can and should be removed by local excision. This can be done as an office procedure. A small amount of 2 per cent Xylocaine solution is placed in the base of the fibroma, the fibroma is excised, and the mucous membrane is closed.

Epulis is a pedunculated fibrous tissue tumor attached to the gingival margin arising from the peridontal membrane. These tumors contain giant cells, and although previously considered by some authorities to be giant cell tumors, the giant cells are not neoplastic but inflammatory and the lesions are designated

of a tooth is contraindicated in the presence of an acute virulent infection with any evidence of cellulitis because of the danger of bacteremia. Extraction should be done only after the infection has been controlled by antibiotics at least 48 hours.

If pointing of the abscess occurs in the buccal mucosa, submucosal fluctuation can be demonstrated. The abscess is drained through an incision made parallel to the margin of the gum after the area has been anesthetized with a local anesthetic. The anesthetic agent should not be injected into the area of the abscess.

Periapical alveolar abscess occasionally points on the outside of the face; this results in an extra-oral fistula. This may present a difficult diagnostic problem if an abscessed tooth is not suspected. Dental consultation will rule out this possibility (Figs. 200, 201).

### TUBERCULOUS ULCER

Tuberculous ulcer is usually larger than simple ulcers and when it attains any size, there is considerable induration. Ulceration is usually preceded by development of small circumscribed submucosal nodules (tubercles which are *likely to be symptomless). They occur* more frequently in men than in women. Almost without exception there is associated pulmonary tuberculosis. Tuberculous ulcers are undermined and quite painful, usually much more painful than syphilitic and malignant ulcers. In contradistinction to syphilitic ulcers, there is usually no associated lymphadenopathy.

The diagnosis of tuberculous ulcer of the buccal cavity can be suspected when the ulcer is extremely painful but is associated with little induration. On the other hand, a positive diagnosis can be made only by biopsy or by excision biopsy.

### SYPHILIS

Syphilis can involve the buccal cavity, particularly the tongue, and may be a primary lesion (chancre), secondary mucous patches or gumma with associated glossitis. Chancres of the buccal cavity usually have a characteristic appearance and respond well to antisyphilitic therapy. Syphilitic glossitis results in atrophy of the papillae with production of areas that appear smooth. Syphilitic glossitis is always associated with a positive Wassermann reaction. It offers a good prognosis with adequate therapy. In addition to glossitis a gumma of the tongue can occur. It is usually deeply placed in the tongue, generally on the dorsum. After the discharge of the center of the gumma, an ulcer develops. Even though the lesion may appear to be a syphilitic ulcer and even though the serologic reaction may be positive, the possibility of an associated malignant neoplasm must be considered and biopsy or excision biopsy must always be done. Syphilitic ulcers of the tongue usually occur in the midline near the base or tip of the tongue and are usually associated with lymphadenopathy.

The treatment of syphilitic lesions of the buccal cavity consists of active and thorough antisyphilitic measures.

### MEDIAN RHOMBOID GLOSSITIS

A relatively rare condition of the tongue, but one which is of importance *because of its similarity to a neoplasm* of the tongue, is median rhomboid glossitis. It is, however, an embryologic defect resulting from failure of the lateral halves of the tongue to fuse before the tuberculum impar becomes interposed between them, just anterior to the circumvallate papillae. It consists of a plaque, usually rhomboid in character, situated in the midline of the tongue immediately anterior to the circumvallate papillae. It usually produces no symptoms and is detected accidentally by the patient or the physician. It usually occurs in middle aged men. Of greatest concern to the physician is that it is likely to be confused with neoplastic lesions and is thought by some to be a premalignant lesion. However, only rarely does it undergo malignant change. Sharp and Bullock[7] reported such a case. Martin and Howe[8] emphasized that it should never be confused with a malignant le-

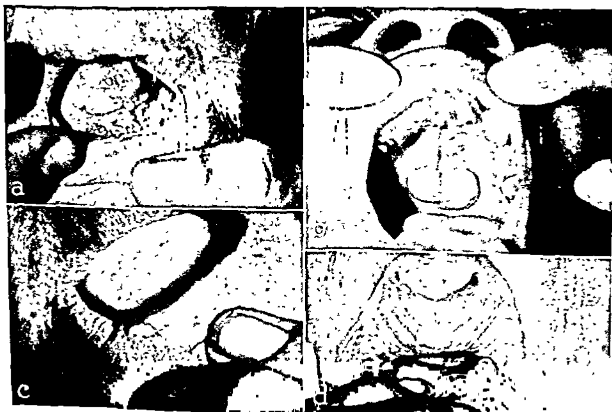
types of leukoplakia that can be differentiated with certainty only by microscopic examination. One is "pachyderma oralis," which he believed is not true leukoplakia although clinically it appears as a white plaque; and the other is "dyskeratosis," which he considered to be true leukoplakia, a premalignant lesion. There is some controversy as to whether pachyderma oralis, which according to Bernier is a "defense thickening," ever progresses to dyskeratosis or whether dyskeratosis always begins as a primary lesion. Probably the question is academic, because it is generally accepted that pachyderma oralis should be treated conservatively and that true leukoplakia (dyskeratosis) should be excised or, at least, treated conservatively for only a short time.

*Pachyderma Oralis.* As a result of chronic irritation, which may be nonspecific such as jagged teeth and poorly fitting dentures, or specific, as the use of tobacco, the buccal mucosa thickens ("defense thickening"). This thickening is similar to that occurring in the skin after chronic irritation (callus). The white discoloration of the thickened area, according to Quinn,[10] is due to the fact that the keratinized area is kept constantly moist by the salivary secretions in the mouth. Similar whitish discoloration occurs in calloused areas of the skin when they have been immersed in water for several hours.

Lesions may vary considerably in size from very small to large, but they are more likely to be localized than dyskeratotic lesions. Women are frequently affected, and the incidence increases with advancing age. There are no areas of predilection.

Lesions consist of hyperplasia of stratified squamous epithelium with increased keratin and varying degrees of inflammatory reaction (Fig. 201). They can be differentiated from dyskeratosis with certainty only by microscopic examination. If a lesion is large, which is less likely than in dyskeratosis, several biopsies should be taken.

Treatment of pachyderma oralis is conservative. First, irritating factors, such as tobacco (either chewing or smoking), excessive use of condiments and astringents,




old-

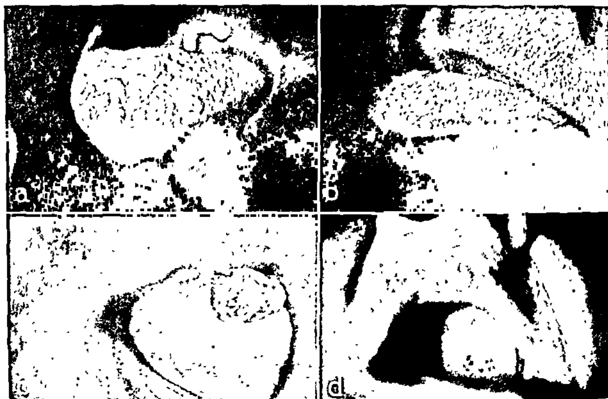


*Figure 202* *a,* Fibroma of tongue. *b,* Papilloma of tongue. *c,* Polypoid papilloma of tongue. *d,* Leukoplakia of roof of mouth.

"peripheral giant cell reparative granulomas." Because epulides are frequently associated with inflammation, trauma or both, they may represent response to trauma. They usually arise at the interdental spaces and may protrude on the buccal or cheek side of the gingival margin.

Treatment of epulis consists in careful exposure, under local or conduction anesthesia, of the attachment of the tumor to the gingival margin. The adjacent tooth or both teeth, if the attachment appears to involve the peridontal membrane of both adjacent teeth, are extracted and the epulis is removed with its attachment to the peridontal membrane.

Other relatively infrequent lesions which are benign tumors are hemangiomas. Although hemangiomas may vary from very small to extremely large, the small ones are usually more frequent. They are usually discovered accidentally by the patient or physician and are of no consequence. Because they are vascular tumors, they bleed considerably if they are injured. If they are at a site where injury might occur, they should be removed. This can be done in the physician's office, although at times it may be hazardous because of the extreme vascularity of the lesion.

Papillomas are usually discovered accidentally. They may be pedunculated or they may have a broad base. They usually produce no symptoms unless they are large enough to interfere with mastication (Fig. 202 *b* and *c*). They may occur anywhere in the buccal cavity, but in the region of the faucial pillars they may be rather large. They must be considered as being premalignant although they are benign tumors. They should be and usually can be removed under local analgesia as an office procedure, unless they are very large.

### LEUKOPLAKIA

An important lesion of the mouth because of its potentialities is leukoplakia, which, as the name implies, is a white plaque (Figs. 202 *d,* 203 *a* and *c*). The term is descriptive, not diagnostic. Because many leukoplakic areas are premalignant, it is extremely important to make a correct diagnosis in every instance. Bernier[3] described two main



*Figure 205.* Dyskeratosis of oral mucosa. There is hyperkeratosis and irregular acanthosis with areas of atypical hyperplasia. Also note the characteristic severe inflammatory reaction in the subepithelial connective tissue. H & E. 17 ×.

differentiating factor, according to Bernier,[3] is "a disturbance in the orderly maturation of the stratified squamous epithelium. It is recognized by changes in the size and shape of the cells, abnormal mitoses (in both frequency and character), nuclear fragmentation, cytoplasmic inclusions, altered staining characteristics, and other abnormalities." The lesion is similar to senile keratosis of the skin and is a premalignant lesion (Fig. 205).

In most cases of leukoplakia, because of the impossibility of differentiating pachyderma oralis from dyskeratosis, it is necessary to obtain a specimen for biopsy and, in large lesions, to remove sections from multiple areas. If true dyskeratosis is diagnosed, the method of therapy is excision of the lesion, although several weeks of conservative therapy, as outlined under pachyderma oralis, might be justified. However, if the lesion does not regress almost immediately, excision should be advised.

### TORUS PALATINUS

A relatively common but usually insignificant lesion is exostosis in the midline of the hard palate, which apparently begins in adolescence. It is twice as common in females as in males and is probably hereditary. It usually increases little in size but may become large in adult life. It is of significance only because it is a tumor and may be confused with a neoplasm that requires therapy. It consists of tumefaction of the spongy bone in the median palatine suture and may vary in size from a very small area to a considerable tumefaction (Fig. 203*b*). It is usually symmetrically distributed on both sides. It is covered with normal mucosa. Usually it is necessary only to reassure the patient that it is of no significance and that nothing need be done, but excision should be advised if there is any chronic irritation of the mucosa overlying the tumefaction or if full dentures are to be worn.

### TORUS MANDIBULARIS

Bony exostoses similar to torus palatinus are occasionally found on the mandible. They occur bilaterally on the lingual aspect of the mandibular alveolus (Fig. 206).



*Figure 206.* Mandibular torus of left side of alveolar ridge.

### SALIVARY CALCULI

Calculi in the salivary ducts are of importance in that they are symptomatic and may produce considerable damage to the salivary glands. They occur much more frequently in males than in females and vary from a pinpoint to several inches in diameter. The submaxillary gland is involved much more frequently than the other glands. Approximately two-thirds of all salivary stones are located in the submaxillary and only about 20 per cent in the parotid gland. Because the calculi contain considerable calcium, they usually can be visualized roentgenographically. Harrison[13] classified the patients into three groups according to



*Figure 201.* Pachyderma oralis. Note the tremendous thickening of the keratinized layer. Compare with true dyskeratosis (Fig 205) taken at same magnification Although the stratum malpighii is also greatly thickened, there is no cellular atypia. There is no significant degree of inflammatory reaction of the subepithelial connective tissue In contrast with true dyskeratosis, this lesion is not premalignant. H & E, 17 X.

must be forbidden. Ill-fitting dentures and jagged teeth must be corrected. If there is clinical or serologic evidence of syphilis, active antisyphilitic therapy is necessary. Because pachyderma oralis is similar in many respects to senile changes in the vagina which respond dramatically to estrogenic therapy, this hormone is used also in pachyderma oralis. Stilbestrol, 5 mg. three times a day, combined with oral administration of crude or dried brewer's yeast, 1 gm. three times a day, and liver extract injections every 10 days as suggested by Nathanson,[11] is of real value. With this therapy, pachyderma oralis will almost invariably regress and, in many instances, areas that appear to have undergone dyskeratotic changes will also regress. If, however, microscopic examination suggests dyskeratosis or if conservative therapy is not successful, the lesion must be extirpated.

***Dyskeratosis.*** Dyskeratosis may occur without any obvious cause but usually follows prolonged chronic irritation. Of greatest importance is smoking, particularly pipe smoking. Bernier[3] is of the opinion that in addition to the local irritating factor, which he designated the "triggering mechanism," there are other conditions that predispose to dyskeratosis ("Conditioning factors"). That such a dual mechanism can occur is evidenced by the recent observations at the Massachusetts General Hospital that cancer of the tongue occurs relatively often among patients with cirrhosis of the liver. Trieger and associates[12] showed that cirrhosis of the liver is a predisposing factor in the production of cancer of the tongue. Of 108 cases of cancer of the tongue which they observed, 48 (44 per cent) had definite cirrhosis. They believed that cirrhosis is a predisposing factor in that it makes the tongue more *susceptible* to the cancer-producing agent, smoking, and that the combination of both is responsible for development of cancer of the tongue. It is, therefore, possible that such a condition exists in the development of leukoplakia as maintained by Bernier.[3] In addition to smoking, the local irritating agent may be trauma from jagged teeth or badly fitting dentures. In the past, syphilis was considered a causative factor and should always be suspected in patients with leukoplakia. Vitamin deficiency, particularly vitamin B, is frequently present.

As in pachyderma oralis, dyskeratosis is evidenced clinically by a white plaque (Fig. 203 *a* and *c*). In contrast to pachyderma oralis, which may be found in any part of the mouth, dyskeratosis most frequently involves the lips, cheeks and gingival tissue followed in frequency by the tongue and palate (Fig. 202*d*). Another differentiating feature is the sharp demarcation between the area of involvement and the surrounding normal mucous membrane. Whereas pachyderma oralis occurs more frequently in females, dyskeratosis occurs predominantly in males.

Pachyderma oralis can be differentiated from dyskeratosis only by microscopic examination. Hyperplasia of the mucous membrane is pronounced and frequently considerable inflammatory reaction is present. The most important

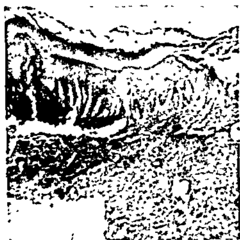


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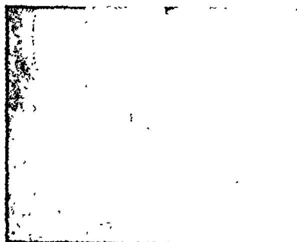


*Figure 207* Roentgenogram showing calculus in left submaxillary gland.

their symptoms: (1) those who have pain and swelling in the region of the involved gland upon eating, particularly acid food; in this instance, the stone is usually small and acts as a ball valve; (2) those who may or may not have a history of recurrent swelling, but who suddenly experience pain and swelling in the region of the involved salivary gland with systemic evidence of infection, such as fever; (3) those who exhibit evidence of extension of the infection and inflammatory process beyond the gland with marked induration in the periadenitic area. If it involves the submaxillary and sublingual glands, the swelling extends to the floor of the mouth.

A stone will be demonstrated roentgenographically (Fig. 207) in approximately 80 per cent of cases. Nonopaque salivary calculi can be demonstrated as negative shadows by sialography. Not infrequently pus can be expressed from the opening of the duct.

Treatment consists in removal of the stone (see p. 489). Small stones in the submaxillary duct or the buccal portion of the parotid gland can be removed by intraoral incision with use of a local anesthetic over the area in which the stone is located. However, in those cases in which the stone is located within the substance of the gland or in which there is considerable destruction of the gland as a result of inflammatory reaction, it may be necessary to extirpate the gland. This is a rather extensive operative procedure and should not be done in a physician's office.

## LESIONS OF THE LIPS

Lesions of the lips are common, particularly in persons who are excessively exposed to the elements, such as sun, rain and wind. Significant pathologic changes of the lip are prone to develop in such people as fishermen, carpenters and farmers, particularly if they have fair complexions. In the beginning these changes are minimal and consist of dryness, scaliness of the mucous membrane, friability and cracking of the mucosa. If allowed to continue, the mucous membrane becomes extremely thickened and may become leukoplakic (Fig. 203*c*). Also as a result of the holding of a hot pipe stem or a cigarette in one particular portion of the mouth, trauma, particularly to the lower lip, can occur, resulting in localized irritation which usually subsides if the practice is discontinued. However, if trauma is continued, a small ulcer develops, the edges of which will become thickened. At this stage it is difficult to differentiate between benign and malignant ulcers (Fig. 203*d*). In any persistent ulcer which does not respond to conservative therapy, the possibility of neoplasm must be considered and an adequate specimen for biopsy obtained. The treatment of nonmalignant lesions of the lip is conservative, that is, avoidance of traumatizing agents such as exposure to the elements, protection of the face from the sun's rays when it is necessary to be exposed to sunlight and application of a bland ointment, such as lanolin, to protect the lips. Generally, this is all that is necessary to bring about complete restitution of normal mucous membrane. If, however, irritation continues in spite of conservative therapy, excision of the lesion and thorough microscopic examination are imperative.

Pigmented patches of the labial and buccal mucosa may be of great diagnostic significance and may be indicative of multiple intestinal polyposis. This syndrome, first described by Peutz[14] in 1921 and further elaborated by Jeghers and



*Figure 208.* Characteristic pigmentation of lip in Peutz-Jeghers syndrome.

associates[15] in 1919, is known as the Peutz-Jeghers syndrome. It is congenital and inherited. The perioral pigmentation consists in melanin-like spots on the lips, usually the lower, and buccal mucosa, occasionally on the gingival and hard palate but seldom on the tongue (Fig. 208). These buccal lesions are of little significance except to call attention to the possible coexistence of intestinal polyps, which are significant because they may ulcerate, bleed, cause intussusception and undergo malignant change.

* * * * *

Malignant lesions of the buccal cavity will not be considered in this text. It is imperative, however, that in all ulcers of the mouth, regardless of their location, biopsies be performed to eliminate the possibility of a malignant lesion. Regardless of how simple the lesion may appear, either extirpation of the entire lesion or biopsy must be done to be sure that the lesion is not malignant.

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*Chapter 17*

# Anus, Perianal and Rectal Regions

*By Patrick Hanley and Merrill O. Hines*

## EMBRYOLOGY AND ANATOMY

In order to understand varied anorectal pathologic conditions and the modern surgical principles in their treatment, familiarity with the embryology, anatomy and physiology of the anorectum is essential. It might be well to review these briefly.

In the 7.5 mm. embryo the tubular allantoic duct expands to form the bladder, which, after receiving the wolffian ducts, continues caudally as the urogenital sinus. Posteriorly, the sinus is connected to the hindgut—the common cavity called the cloaca. In the seventh week there is dimpling of the anal pit forming the proctodeum. This inpocketing continues until the proctodeum and rectum join their lumens by rupture of the anal membrane. The anal canal is of ectodermal origin, the rectum of entodermal origin. Union of these two structures forms the dividing line between the visceral and somatic nervous systems, the portal and caval circulation and the visceral and somatic lymphatics. This junction, which is an irregular line of demarcation known as the anorectal, [illegible]

[illegible] anal sphincter forms longitudinal mucosal folds of the rectal mucosa (columns of Morgagni) which terminate at the dentate line. The junction of the anal skin and rectal mucosa at the base of each column of Morgagni is sometimes identified by the presence of a teatlike structure known as the anal papilla. The anal papilla with or without the base of the rectal column is connected by a thin semilunar fold of epithelium called the anal valve. The anal valve and papilla are of ectodermal origin. The cuplike spaces thus created are known as the anal crypts. The anal canal is lined with modified skin. The junction of the middle and upper thirds of the anal canal represents the "white line of Hilton," or, more anatomically, the intersphincteric line or intermuscular septum (Fig. 233).

The pectin refers to the upper third of the anal canal, between the dentate line and the intersphincteric line. The pectin is important, for the preformed anal duct and intramuscular glands are present in the subepithelial areolar space. Anorectal glands are independent structures, and it is the consensus that these preformed tubular ducts are accountable for the frequency of anal infection because of their frequent connection with the anal crypt. Knowledge of these structures will greatly assist in understanding the pathogenesis of inflammatory diseases of the anorectum.

*Sphincter Muscles.* The circular layer of nonstriated muscle of the rectum terminates as the internal sphincter. The latter structure, which encircles the upper two-thirds of the anal canal, extends from the anorectal ring to the intermuscular septum and is surrounded by the superficial and deep portions of the external anal sphincter. The sympathetic and parasympathetic nervous systems supply the innervation. The longitudinal muscle of the rectum terminates by dividing, at the inferior level of the internal sphincter, into a medial portion that separates the internal and subcutaneous external sphincter and inserts into the skin as the corrugator cutis ani. The lateral extension separates the sub-

cutaneous from the superficial external sphincter and the perianal from the ischioanal space (Fig. 233).

The external sphincter muscle is voluntary. It is composed of three distinct striated muscle bundles:

1. The subcutaneous external sphincter, located at the lower anal margin, is immediately under the skin, just below the level of the internal sphincter, and is separated from it by the fibro-elastic intermuscular septum which forms the "white line of Hilton." The muscle has no bony attachments.

2. The superficial bundle of the external sphincter has its origin from the dorsal lateral aspects of the coccyx and the anococcygeal raphe. The fibers extend anteriorly in an elliptic fashion and divide to encircle the anus at the lower level of the internal sphincter. Anteriorly, some of the fibers may decussate, terminating in the superficial tranverse perinei muscles or in the central tendinous raphe.

3. The profunda, or deep external sphincter bundle, is above and lateral to the superficial bundle, and is like the subcutaneous in its annular shape and attachments. The posterior fibers are intimately associated with the puborectalis.

The puborectalis has its origin from the pubic bone, is a part of the levator ani muscle, and forms a sling about the lower rectum. It is this muscle that draws the anal canal anteriorly upward and forms the upper limits of the anorectal ring. The puborectalis posteriorly increases the depth of the anorectal ring as compared with the anorectal ring anteriorly. The nerve supply is from the second, third and fourth sacral plexuses through the inferior hemorrhoidal and perineal nerves.

*Potential Spaces. Pararectal Spaces.* These are potential areas of infection about the rectum above the level of the levator ani muscle and are supralevator spaces.

1. PELVIRECTAL SPACES. There are two pelvirectal spaces. They are bound above by peritoneum, inferiorly by the fascia of the levator ani, anteriorly by the vagina in the female and the seminal vesicle and prostate in the male, and posteriorly by the lateral rectal stalk.

2. THE RETRORECTAL SPACE is directly behind the rectum and anterior to the sacrum, extending from the levator ani to the peritoneal attachments to the rectum superiorly, and bounded anteriorly by the rectal stalks of Jonnesco.

*Para-anal Spaces.* These are located below the levator ani muscles and are infralevator spaces.

1. ISCHIOANAL SPACES. There are two ischioanal spaces which are roughly triangular in shape, the base being formed by the skin between the anus and the tuberosity of the ischium. The lateral wall is formed by the tuberosity of the ischium and the fascia and muscle of the obturator internus, superomedially by the levator ani, inferomedially by the anal canal, posteriorly by the gluteus maximus muscle and sacrotuberous ligament and coccyx, and anteriorly by the transverse perinei muscles and perineal (Colles') fascia. Posteriorly, in the midline just above the superficial external sphincter, the ischioanal spaces are connected and pus may penetrate from one ischioanal space to the other, forming the common horseshoe abscess.

2. THE PERIANAL SPACES surround the lower third of the anal canal. Posteriorly the perianal space is divided into a superficial and a deep postanal or posterior triangular space. The superficial space is below the superficial external sphincter, and the deep postanal space is located above the superficial sphincter and below the levator ani; this is the space that connects with the ischioanal spaces. The perianal space is separated from the ischioanal spaces by the lateral termination of the longitudinal muscle layer of the rectum. For detailed description of the anatomy of this region the reader is referred to the textbooks of Bacon[1,2] and Gorsch.[3]

## EXAMINATION OF THE ANAL CANAL AND RECTUM

No physical examination is complete without examination of the anorectum. This means examination of the anal ca-



*Figure 209.* Position of patient for anorectal examination. *A*, On proctologic table; *B*, Sims position; *C*, knee-shoulder position.

nal as well as the rectum. Too frequently the medical student or intern will perform a digital examination of the rectum without evaluating the anal pathologic alterations present. Practically all infectious inflammatory diseases of the rectum originate in the anal crypt of Morgagni, and invariably they leave some evidence of existing chronic forms of infection that are readily detected by careful examination.

Whereas the Buie or Hanes proctologic tables are ideal for carrying out examinations (Fig. 209*A*), the left lateral Sims position (Fig. 209*B*) or the knee-shoulder position is entirely satisfactory (Fig. 209*C*). The patient is placed in the left lateral position on a regular examining table or near the edge of a bed. The thighs are flexed on the abdomen about 45 degrees and the legs are bent sufficiently to make the patient comfortable but with the feet out of the way of the examiner. The patient can be made more

comfortable if a pillow is placed between the knees. Proper draping and utmost gentleness must be employed to alleviate fear and apprehension and to gain the patient's confidence. Every effort should be made to minimize the feeling of embarrassment. The left lateral Sims' position is excellent for inspection and for digital and rectosigmoidoscopic examinations. Inspection is accomplished by gently placing the hands over each buttock near the anus and slowly separating the buttocks. This phase of the examination is painless in normal patients. Pain always means anorectal disease and the examiner must proceed with a more gentle touch.

*Digital Examination.* The finger must not be pushed into the rectum, for when it touches the anal skin the anal sphincter contracts. The examiner should therefore hesitate a few seconds before gradually inserting the finger as the muscle relaxes. This will minimize the discomfort to the patient. Before the finger is inserted further (Fig. 210), careful palpation of the posterior wall of the anal canal, where over 90 per cent of anorectal inflammatory disease is located, is an excellent practice, for some residual fibrosis and induration frequently can be better felt than seen. Severe pain on digital examination is strongly suggestive of an anal fissure. Occasionally, in patients with acute anal fissure, analgesic ointments or local, or even sacral or spinal, anesthetics may be necessary for an adequate examination. The tone and function of the sphincter should be evaluated.

*Bidigital examination* can be accomplished by grasping the entire sphincter mechanism between the index finger and thumb (Fig. 211). This is an excellent maneuver to detect the direction of the cordlike tract of a fistula-in-ano, atrophic fibrosis of an otherwise normal sphincter mechanism, early anal sinuses or other abnormalities. Upon completion of the anal examination the finger should be inserted deeply into the rectum (Fig. 212), the tip of the finger being manipulated above the valves of Houston or angulations to obtain maximum depth. Pathologic changes 12 to 13 cm. or more

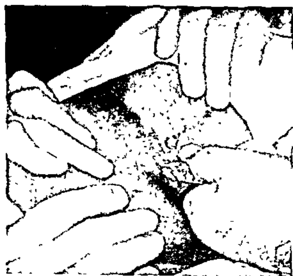


*Figure 211.* Bidigital examination will detect abnormalities of sphincters, anal canal and perianal region.

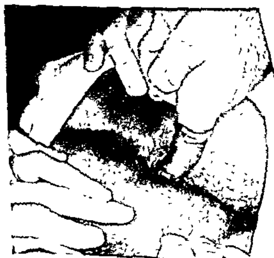


*Figure 210.* Anal canal should be palpated before performing rectal examination.

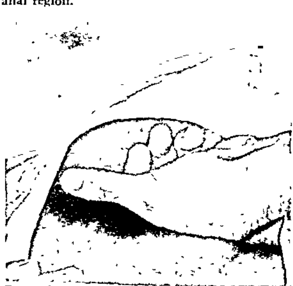


*Figure 212.* Rectal and presacral examinations.

from the dentate line are frequently palpable. This is made possible by telescoping the rectum about the examining finger. Careful palpation will permit diagnosis of most intraluminal rectal diseases, and over 70 per cent of all malignant diseases of the colon.

Cursory palpation will fail to provide information necessary to diagnose many mucosal or submucosal lesions. The finger must press the rectum against the sacrum or adjacent organs to detect submucosal carcinoid, benign lymphoma, lipoma, fibroma, endometriosis, polyps and early cancerous lesions. Special emphasis should be placed on palpation of the lower posterior rectum, for this is frequently a blind spot during proctoscopy. Palpation should be done not only to discover tumors but also to determine abnormal consistency of the mucosa or the wall of the rectum. In amebic ulcerations multiple indurated ulcerations with normal intervening mucosa may be felt. In ulcerative colitis the diffuse cobblestone irregularity of the mucosa is characteristic, and in chronic cases the ampulla is contracted and fibrotic. In lymphopathia venereum the rectum feels like a smooth rigid tube, and stricture of the rectum is common in the Negro female. The coccyx can be carefully examined bidigitally for sacrococcygeal disease with the index finger in the rectum and the thumb over the external surface. In the female with rectovaginal septal disease, bidigital examination with the index finger in the rectum and the thumb in the vagina provides added information.

After intraluminal examination, extrarectal disease should be ruled out by a sweeping motion of the finger from right to left to palpate the sacrum and posterior true pelvis. Chordoma, teratoma, dermoid cyst, neurofibrosarcoma, and pelvic Hodgkin's disease are a few of the extrarectal tumors that are palpable in the presacral region. If the hand is kept still with the palm directed posteriorly and the examining finger is extended, pathologic conditions can be felt in the cul-de-sac at a much higher level than if the hand is rotated to the palm-down position. With the hand in the position shown in Figure 213, the prostate, seminal vesicles, base of the bladder, cul-de-sac and extrarectal tumors can be evaluated. In the female the cervix, fundus of the uterus and ovaries must not be erroneously interpreted as extrarectal disease. Direct extension of carcinoma of the cervix to involve the rectum, or infiltration into the broad ligament or along the posterior uterosacral ligaments, is of prognostic value. Brawny, fibrotic, smooth induration and fixation in the region of the cervix and broad ligament are not infrequent sequelae of irradiation of the cervix for malignant growths. Irregular fixation and multiple or single nodules in the cul-de-sac or para-adnexal area usually represent endometriosis, which at times can be extraperitoneal. The cul-de-sac is a likely place for metastatic transplants; sometimes this is the only positive physical finding in undiagnosed carcinoma of the pancreas, stomach and gallbladder. The metastatic lesion increases in size and can be felt as an indurated mass in the cul-de-sac. This cul-de-sac mass is usually fixed, nontender and firm, and has a nodular surface. Very early cul-de-sac seeding is not necessarily fixed. This condition, which is referred to as a rectal shelf or Blumer's shelf, is of utmost importance in prognosis. If indefinite or ill defined masses are palpable in the cul-de-sac in a patient



*Figure 213.* Palpating structures anterior to rectum.

who has not had the necessary preparation for examination, the examination should be repeated after the colon has been cleansed with a saline enema.

*Anoscopy* and *proctoscopy* should follow all digital examinations. For adequate examination the colon must be clean; otherwise small polyps and other lesions may not be detected. The colon may be cleansed by having the patient take saline enemas, one teaspoonful of salt to each quart of water, until the returns are clear, two or three hours before examination. There are many types of anoscopes and proctoscopes available, all of which are good once the examiner has become accustomed to using them. A long 6-inch Hirschman's anoscope is superior to the shorter instruments in the deep-seated anal canal of the muscular patient; this is especially true in the Negro male, where examination can be carried out to the anorectal ring without difficulty. The lubricated anoscope is grasped by the handle with the fingers and the thumb in place over the obturator and is gently placed at the anus, directed toward the umbilicus. Gentle intermittent pressure will permit the sphincter to relax and the scope to enter the rectum with minimal discomfort. It is imperative that the examiner give the sphincter sufficient time to relax. With this instrument chronic anal ulcers, acute anal fissures, anal squamous epitheliomas, internal hemorrhoids, hypertrophied anal papillae, low rectal polyps and carcinoma, cryptitis, acute papillitis, and the primary opening of a fistula-in-ano can be visualized. The entire circumference of the anal canal should be inspected. Better evaluation of internal hemorrhoids may be obtained if the patient is requested to strain down to engorge the hemorrhoid during anoscopy.

*Sigmoidoscopy* after anoscopy increases to 80 per cent the chances of diagnosing cancer of the colon. Adenomatous polyps are potentially premalignant lesions, which are encountered in about 8 to 10 per cent of cases. It is readily understandable that performance of sigmoidoscopy in more patients, with eradication of these premalignant lesions, is one of the best available prophylactic measures against cancer. Sigmoidoscopy is the only method of diagnosing asymptomatic carcinoma of the lower sigmoid and rectum in the early stages. In a clean intestinal tract small sessile polyps 2 mm. in diameter are easily detected. Proctoscopy is mandatory as a routine procedure in patients over 40 years of age and in all patients, regardless of age, who complain of rectal bleeding or other colonic symptoms. Fluoroscopy and barium enema roentgenograms are unreliable in the diagnosis of rectal or lower sigmoid lesions. A normal roentgenogram is not sufficient evidence to assure a patient that he does not have rectal or low sigmoid cancer.

The proctoscope is inserted in the same manner as is the anoscope, the instrument being directed toward the umbilicus (Fig. 214*A*). When the instrument passes the sphincter the obturator is removed and the procedure is continued under direct vision. After removal of the obturator, air will enter the proctoscope and distend the bowel. The distention from this atmospheric pressure is frequently sufficient to permit examination without the aid of mechanical hand insufflation. Inflating the colon with the attached hand bulb causes abdominal cramps and increases the patient's discomfort. It should therefore be done with discretion and only when necessary. Insufflation is contraindicated in patients with acute diverticulitis, subacute perforation, acute ulcerative colitis or traumatic perforation. Precaution to prevent mucosal trauma or perforation of the intestine must be constantly borne in mind, and when the proctoscope reaches an angulation no attempt should be made to force it past this spot. Inflating the intestine not only causes the patient to have more pain but the angulation frequently becomes more acute and impassable. At times it is better to release the air from the colon completely, withdraw the proctoscope a little and, by slow, gentle manipulation in the direction of the intestinal lumen, actually telescope the proximal intestine on the

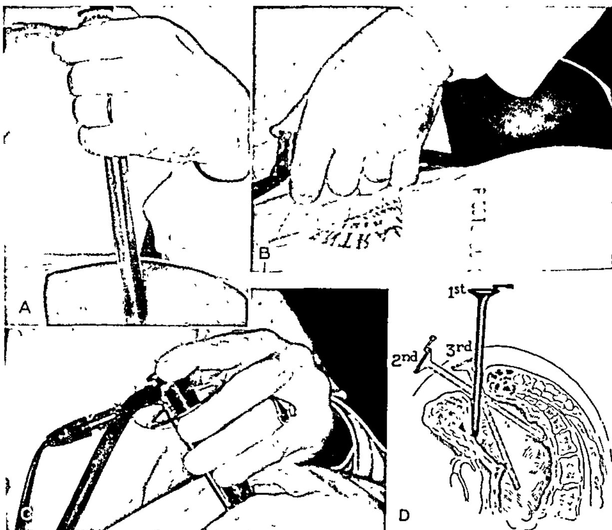



*Figure 214.* Proctoscopy. *A,* First maneuver—proctoscope directed toward umbilicus. *B,* Second maneuver—proctoscope directed into hollow of sacrum (little finger acting as fulcrum). *C,* Third maneuver—above the promontory of the sacrum the proctoscope is more or less directed to the umbilicus parallel to the first maneuver *D,* Diagrammatic illustration of the three maneuvers of proctoscopy.

proctoscope. The first, most difficult angle is usually at the rectosigmoid junction, 16 cm. from the dentate line. Once the proctoscope passes the anal canal, the direction is posteriorly into the hollow of the sacrum, almost at a right angle to the initial direction. Holding the proctoscope with a firm grip, as shown in Figure 214*B*, will increase maneuverability, with the examiner's little finger acting as a fulcrum instead of the anus. As the upper rectum and rectosigmoid are approached, the direction of the instrument again changes and is more or less parallel to the initial maneuver (Fig. 214*C* and *D*). One can usually determine when the sigmoid is entered, for the mucosa has multiple transverse folds whereas the rectum has a smooth surface.

During introduction of the proctoscope the examiner should concentrate on getting the instrument as high as possible without perforating or otherwise injuring the intestine; he should not be concerned with diagnosis until this has been accomplished, for diagnostic examination is performed only during withdrawal of the instrument. Just before removal of the proctoscope the intestine should be inflated with only sufficient pressure to distend it; this makes possible inspection of the entire mucosal surface. The proctoscope should be withdrawn with a rotary motion. Valves of Houston should be ironed out flat to be

certain that small lesions on the superior surface are not overlooked. Just before removal of the proctoscope the blind spot should be inspected, just above the anorectal ring posteriorly.

### Diagnostic Proctoscopy

*Normal Proctoscopic Observations.* Normally, the rectal ampulla is voluminous when distended with air and the crescentic folds, the valves of Houston, are noticeable. The right valve of Houston is roughly at the level of the peritoneal reflection over the anterolateral aspect of the intestine. On the left side the valves of Houston are below and above the level of the right valve. The valves of Houston, which are rather thin, sharp edged, soft and flexible, transilluminate readily. The rectal mucosa is smooth and pale pink, with a prominent vascular pattern. At the rectosigmoid junction (16 cm.) there is an abrupt change; the mucosa presents multiple transverse folds, the vascular pattern is less prominent, and the diameter is decreased. The thin sigmoid is frequently of sufficient transparency to permit observing loops of small intestine moving in the cul-de-sac.

*Amebic Proctitis.* Amebiasis is encountered in about 5 per cent of patients consulting a proctologist. Amebic ulcers appear as scattered, discrete, round or oval ulcers varying in size from 1 mm. to 2 cm. or even larger at times. There may be only a few or the involvement may be diffuse and coalescent. The ulcer is slightly raised above the mucosal level. The edges are ragged and undermined with a dirty, necrotic appearing, grayish base. The immediate margin of the ulcer is usually ringed with a small area of hyperemic mucosa. The intervening mucosa is normal, except in severe cases. Examination of a specimen from the ulcers usually reveals *Endamoeba histolytica* trophozoites. Large chronic amebic ulcers that are secondarily infected lose their characteristic gross features. The ulcers usually extend to the muscle layer. Untreated ulcers may perforate.

*Ameboma.* Digital palpation of amebic granuloma of the rectum gives the immediate impression of a malignant growth; however, there is something about its characteristics that resembles sarcoma more than carcinoma. The tremendous perirectal induration, swelling and fixation constrict the lumen of the intestine. The mucosal surface is irregular because of ulcerations, but the characteristic rolled edge of carcinoma is absent. Inferiorly the stricture is more or less conical in shape on the end. Inspection reveals a stenotic lumen at the site of the ameboma and deep ulceration in the mucosa, which may actually be gangrenous with sloughing. Deep biopsies of the mass can be obtained with only minimal bleeding. The histopathologic diagnosis is chronic inflammation. Typical small amebic ulcers may be detected below the ameboma. The diagnosis is readily made by immediate microscopic study of a warm specimen and the finding of *E. histolytica* trophozoites. The tumor "miraculously" disappears with proper therapy. There is no residual deformity, or only minimal scarring of the mucosa.

It cannot be overemphasized that the presence of amebiasis is frequently associated with carcinoma of the colon. In endemic areas this is frequently responsible for delayed diagnosis of carcinoma of the colon, particularly if the physician relies solely on the fecal examination for diagnosis. For this reason, complete sigmoidoscopic and roentgenographic studies of the colon are imperative in all patients with amebiasis if coexisting carcinoma is to be detected early.

*Mucous Colitis.* Mucous colitis is a noninflammatory functional syndrome characterized by excessive mucous secretion in the intestine with no diagnostic pathologic changes in the mucosa. The mucosa, which is covered with mucus, appears very moist, shiny and slick and the vascular pattern may be somewhat obscure.

*Bacillary Dysentery.* The appearance of the mucosa in bacillary dysentery depends on the stage of the disease. In the acute phase the mucosa is diffusely hyperemic, edematous and covered with minute shallow bleeding ulcers. The edges are not undermined; they appear

punched-out. A thin fibrinous membrane may be adherent to the surface in spots. In a later phase a pseudodiphtheritic membrane may appear over the ulcerated mucosa that is now dark red or grayish red. The ulcers coalesce, making a serpiginous outline that tends to encircle the intestine. The intervening mucosa is inflamed. The valves of Houston are thickened, rounded and retracted. In this late stage it may be impossible to differentiate the condition from idiopathic ulcerative colitis.

***Ulcerative Colitis.*** In idiopathic ulcerative colitis the endoscopic appearance depends on the stage of the disease. In early cases several examinations may be required before the diagnosis can be made. The sigmoidoscopic appearance is constantly changing and variations are noted from time to time. The pathologic appearance is characterized by diffuse involvement, beginning in the rectum in over 90 per cent of the cases, and spreading to the entire colon and at times the terminal ileum in an antiperistaltic fashion. In the early stage the mucosa presents a mottled appearance, due to pinpoint petechiae and minute papules that are gray to yellowish and may be vesicular. They are slightly raised above the surface of the mucosa. The vascular pattern is normal. The mucosa is slightly edematous. It is this stage that necessitates observation and repeated examinations before a definite diagnosis can be made.

In the second stage the mucosa is diffusely and acutely hyperemic and edematous. The vascular pattern is obscured. There are numerous small, shallow ulcers. The mucosa is moist, slick and covered with excessive mucoid exudate; at times there may be purulent exudate with bloody mucus. The mucosal surface has a fine granular appearance, is friable and bleeds quite briskly after slight instrumental trauma. The valves of Houston are moderately thickened and retracted, and the edges are rounded.

In the third and fourth stages there is no normal appearing mucosa. The ulcers by confluence become larger, varying in size from a few millimeters to 6 or 8 cm. in length and 1 or 2 cm. in width. Usually the large ulcers are in the longitudinal axis of the intestine. There is considerable undermining of the edges and frequently the ulcers are joined by an undermining honeycomb-like pattern under the remaining mucosa. The ulcers have a dirty, yellow or grayish necrotic base; however, at times the muscle fibers can be plainly seen. Some ulcers extend to the serosa. Pseudodiphtheritic membrane may cover the mucosa in spots. Yellow necrotic and sloughing mucosa due to a thrombo-embolic process in the submucous layer is frequently present. The intestine is friable, and bleeding may be so excessive with the slightest trauma that observation becomes most difficult. The disease may persist until death or may heal slowly during a remission.

In the final chronic stage the healing process results in fibrotic contraction of the intestine, often referred to as a "pipestem" bowel. The intestine is narrowed and shortened, with complete obliteration of the haustrations and valves of Houston. The mucosal surface is granular and friable and is covered with a thin, watery, sanguinopurulent exudate. The intestine is thickened and chronic edema is present. Hyperplastic polypoid areas are common and stricture formation is not unusual. Fistula-in-ano and anal ulcers are frequent complications[4] As these patients are usually acutely ill, proctoscopy should be done without preparation and usually should be discontinued when the first angulation is reached, because of the friability of the intestines.

***Melanosis coli*** is recognized as a melanotic discoloration of the mucosa caused by deposition of pigment in the tunica propria of the mucous membrane. The etiology is unknown but this condition usually occurs in patients with constipation who habitually take cascara. The discoloration involves the entire colon, stopping at the ileocecal valve with a sharp line of demarcation. The color of the mucosa varies from light to dark brown to black. The pattern is striking and once observed will never be

mistaken on future examinations. The discoloration of the mucosa is not solid but appears in small, irregular, square or polyhedral areas measuring from 2 to 4 mm. in size which are distinctly separated by a fine, thin, yellowish or grayish line or zone. Whereas melanosis coli is undesirable, there is no clinical evidence that the condition predisposes to disease of the colon, and medical management of the colonic stasis and constipation is all that is necessary.

*Endometriosis.* In women between the age of 20 and the menopausal years endometrioma may infiltrate the rectum and cause symptoms of obstruction or rectal bleeding in rare instances. The anterior half of the rectum at the level of the cul-de-sac or upper rectovaginal septum is the most frequent site of involvement. The obstructive symptoms are not due to encircling constriction, as in carcinoma, but rather to encroachment of the lumen by the tumor pushing into the lumen with fixation of the anterior intestinal wall. The pathologic process is most frequently observed as a bulging of normal intact mucosa, with induration and fixation of the rectal wall. A hard, firm, indurated mass is palpable under the mucosa with the tip of the proctoscope, if above the level for digital palpation. At times the mucosa may be fixed to the mass and on rare occasions it is actually ulcerated.

Biopsy is the only method of definitely confirming the diagnosis. The tissue must be obtained from the submucous layer, and results are more successful if the biopsy is performed during or immediately after menstruation.

*Lymphopathia Venereum.* The proctoscopic appearance of lymphopathia venereum varies with the stage of the disease. In the acute phase the lower rectal mucosa is acutely inflamed, bright red, edematous and friable. Macular, papular and vesicular lesions and multiple ulcerations with a dirty, grayish necrotic base are frequently present. The mucosa is covered with a mucopurulent exudate. Later it is granular, thickened and friable. The bowel is contracted and the valves of Houston are retracted. Smooth strictures are sometimes seen. Mucopurulent exudate still persists. In the old chronic and quiescent cases the bowel becomes rigid and is tubular. The mucosa is smooth and atrophic and sometimes replaced in areas with white plaques of scarring. Smooth fibrotic strictures varying from a few millimeters to several centimeters in length are present.

*Diverticulosis.* The incidence of diverticulosis varies between 5 and 10 per cent in patients more than 40 years of age; of those with diverticulosis, 20 per cent will have diverticulitis. Approximately one-fifth of the latter group will require surgical treatment.

Whereas diverticula may extend downward to involve the mid rectum, most of them are encountered in the sigmoid. A diverticulum is recognized by its usually narrowed stoma, which appears as a little hole in the intestine. The stomas vary from 1 to 5 mm. in diameter. It is practically impossible to determine the depth and size of the diverticulum except by roentgenographic study. At times the stoma is so large that the intestine appears abnormally sacculated and the true course of the intestinal lumen is confusing to the proctoscopist. Owing to the thin serosal and mucosal thickness of diverticula, the intestine should not be excessively inflated for fear of rupturing the diverticulum.

In diverticulitis great spasm and irritability make proctoscopy difficult and painful. The pericolic inflammatory process narrows the lumen, causing varied degrees of intestinal obstruction. The intact mucosa is hyperemic and edematous. Pericolic suppuration at times can be diagnosed by the exuding of purulent material into the lumen of the intestine through a small, almost unrecognizable defect in the mucosa. The proctoscopic inspection in acute diverticulitis is limited to the depth obtainable without insufflation or attempts to pass above the angulated intestine, for such maneuvers are frequently followed by acute exacerbation of the infection.

*Factitial Proctitis.* In the treatment of malignant growths of the cervix and uterus with radium or roentgen ray, ad-

jacent organs and tissues may receive radiation damage. Such damage to the rectum is manifested by typical proctitis. Buie and Malmgren[5] in 1930 were the first to describe this condition, which they called factitial proctitis.

The appearance of factitial proctitis depends on the dose of roentgen ray or radium applied to the cervix or uterus and the interval between irradiation and examination. The proctitis is usually located at the level of the cervix, about 7 to 9 cm. from the dentate line. It is not unusual for the terminal ileum or a loop of sigmoid resting in the cul-de-sac to be similarly involved. The acute stage generally appears 3 to 5 weeks after irradiation. The mucosa is acutely edematous, hyperemic and friable; it bleeds readily after the slightest trauma. The involvement is segmental, usually only a few centimeters in length, and in more than 90 per cent only the anterior rectal wall is involved; in severe cases the entire circumference of the intestine may be inflamed. Induration and fixation of the perirectal tissue in the involved region are present. If the inflammatory process does not advance to the ulcerative stage, the acute inflammation gradually subsides, and the mucosa becomes granular and atrophic and is fixed to the submucous layer with telangiectasis about the lesion. If the process progresses, the edematous mucosa becomes gangrenous and sloughs and leaves a raw, friable, granular surface with areas of granulation and residual spots of grayish and yellow necrotic tissue in the process of sloughing Factitial proctitis is self-limiting and heals ultimately. The healing is always slow, usually requiring one to three years, and it leaves a permanent scar. The mucosa may appear normal on cursory observation, but careful examination will reveal a granular surface that blanches readily when slight pressure is exerted with the tip of the proctoscope. The mucosa is fixed to the intestinal wall and telangiectasis is present. Severe irradiation destruction heals with the formation of a short tubular stricture that may cause sufficient intestinal obstruction to necessitate surgical resection of the involved segment. In some patients rectovaginal fistula results. Malignant change must be considered when ulceration develops 10 to 15 years after factitial proctitis.

During the acute phase when the lumen is compromised the only treatment necessary is to keep the intestinal tract clean by having the patient take warm enemas daily. A low residue diet and vitamins have also proved helpful.

### MALFORMATIONS OF THE ANUS AND RECTUM

Congenital anomalies of the anus and rectum are extremely rare. They are reported to occur once in every 5,000 to 10,000 births. Malformations develop during the sixth to the ninth weeks of embryonic life (see *Embryology and Anatomy*, p. 281).

The classification of congenital anorectal anomalies proposed by Ladd and Gross[6] is used by most physicians because it is most practical in determining therapy and prognosis. Type I is the result of incomplete rupture of the proctodeum, producing stenosis at the anorectal junction (Fig. 215). Type II results from failure of the anal plate or proctodeum to rupture, the thin membrane causing complete obstruction (Fig. 215).

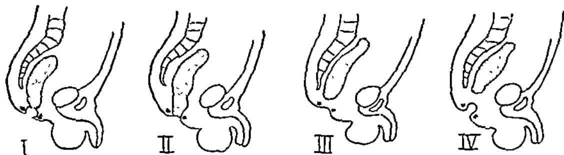



*Figure 215.* Diagrammatic illustration of four types of congenital anorectal malformation.

In type III the blind end of the rectum terminates above the imperforate anus at a varied distance (Figs. 215 and 216). In type IV the anal canal is completely formed but ends blindly and is separated for variable distances from the rectal pouch (Fig. 215).

Failure of the anorectal fold completely to separate the urinary and rectal anlagen results in rectovesical, recto-urethral and rectoperineal fistulas in the male (Fig. 217). In the female the müllerian duct, which forms the uterus and vagina, descends in the urorectal fold so that the fistula usually connects with the vagina (Fig. 218) or the perineum (Fig. 219).

Type III is the commonest congenital anorectal malformation, occurring in more than 80 per cent of cases. Rarely are fistulas associated with types I, II and IV, but they are commonly found in type III. They are reported to be encountered in 52 to 87 per cent of cases of type III. In the female the associated fistula is rectovaginal in the majority of cases. The vaginal opening is usually in the lower third, most frequently in the fossa navicularis just outside the hymen. The perineal fistula may be located in the midline between the posterior fourchette and the anal dimple. In the male, rectovesical and recto-urethral fistulas combined are more prevalent than recto-perineal fistulas. The external opening may be located in the midline from the base of the penis to the anal dimple.

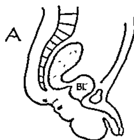


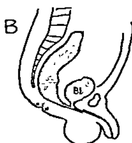
*Figure 216.* Photograph of imperforate anus, type III.

The external sphincter has been reported by some to be absent; however, this is the exception, for the sphincter develops from the mesenchyme and is independent in its development from the ectoderm or entoderm of the anus or rectum.

*Treatment.* Some patients with type I anorectal malformations can be successfully treated by repeated dilations with graduated soft gum rubber dilators until the little finger can enter the anal canal and be used as the dilator. In patients with a partial, persistent anal membrane or severe stenosis of the anal canal a more successful result may be obtained from some type of anoplasty.

In type II the diagnosis is ascertained by the dark discoloration of the skin over the anal dimple due to meconium in the rectum. The thin anal plate forms a complete obstruction at the anal outlet. If the patient cries or strains, the dark anal skin is seen to bulge. Treatment consists in making a cruciate incision through the anal membrane exactly in the anatomic center of the sphincter mechanism; great care and precision must be employed to avoid severing the sphincter muscle fibers, which are im-



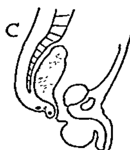




*Figure 217.* Diagrammatic representation of imperforate anus, type III, with associated fistula in the male.

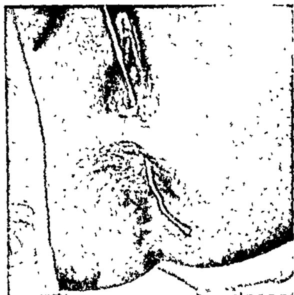


*Figure 218* Postoperative photograph of imperforate anus, type III, with uncorrected rectovaginal fistula.

mediately under the skin. Thereafter, dilation should be performed twice daily until the wound has healed. This procedure requires hospitalization and should be done outside of the hospital only in rare emergencies.

In types III and IV with complete obstruction, surgical correction within 24 to 48 hours is mandatory. In patients in this group with associated rectovesical or rectourethral fistulas, early surgical intervention is also indicated. Varied surgical procedures have been advocated, including definitive initial rectoplasty by the perineal route alone or by the combined abdominoperineal technique. This is a major surgical procedure requiring great skill and should, therefore, be performed only by those experienced in the technique, for the functional result obtained depends on the initial operation and those requiring a second operation usually obtain poor functional results. In some of these infants it may be deemed advisable to establish a defunctioning left transverse colostomy and defer definite rectoplasty until the baby is two or three years old.

In some patients with type III malformations associated with rectovaginal or rectoperineal fistula (Fig. 219), the danger of the development of intestinal obstruction or urinary infection is minimal. Since a true surgical emergency does not exist in some cases, it is wise to defer operative correction 6 to 12 weeks. This gives the infant time to develop and also permits the physician to evaluate associated anomalies, which occur in 28 to 46 per cent of cases and in many cases represent a contributing cause of death. In most of these patients anorectoplasty can be performed without severance of the anal sphincter and without performance of a colostomy.

#### POLYPOID LESIONS OF THE RECTUM AND COLON[7-10]

Polyps of the rectum and colon are potentially malignant neoplasms. The reported incidence has varied from 3 to 11 per cent. These lesions are encountered most often in men between the ages of 40 and 60 years. Grossly, benign adenomas are classified as sessile or pedunculated, the former being four times more prevalent than the latter (Fig. 220). Most polyps are less than 0.5 cm. in diameter but they may be as large as 10 cm. in diameter. Polyps are located chiefly in the rectum and lower sigmoid and are readily diagnosed by proctos-

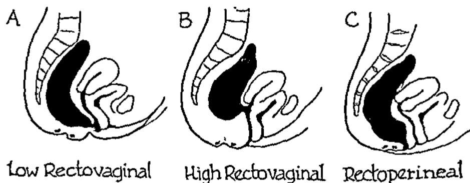



*Figure 219.* Schematic representation of imperforate anus, type III, with associated fistula in the female.

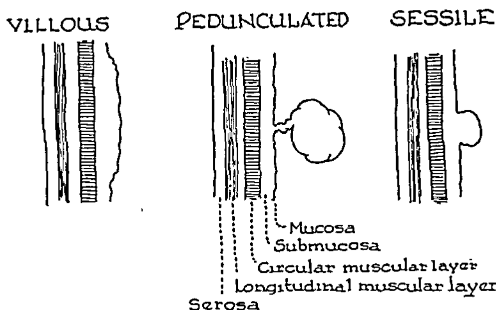



*Figure 220.* Diagrammatic representation of various types of polyps.

copy. Approximately 75 per cent of polyps can be treated in the office without sedation or anesthesia at the time of the initial examination.

***Benign adenoma*** is the most frequently encountered neoplasm of the rectum and colon. It varies from 2 mm. to several centimeters in diameter. Most are sessile but the larger polyps are pedunculated. The sessile lesions are usually smooth and of normal mucosal pink color (Fig. 221). The larger pedunculated polyps have a granular surface (Fig. 222) and some may be nodular or lobulated (Fig. 223A,B,C). The pedunculated polyps are deep red or rusty colored. The pedicle varies greatly in diameter and length, depending on the stretch and redundancy of the mucosa caused by the peristaltic pull on the polyp. The pedicle of benign polyps is always soft, pliable and of normal mucosal color. Induration and ulceration of a polyp are suggestive of malignant change. Induration of the pedicle or mucosa is diagnostic of probable carcinomatous invasion.

*Treatment.* Most polyps can be treated in the office. Sessile and pedunculated polyps that do not present a diagnostic or therapeutic problem are best removed at the time of initial proctoscopic examination, for this will not only save time but it will spare the patient the discomfort of another examination. No anesthetic is necessary. A small sessile polyp should be excised with a biopsy

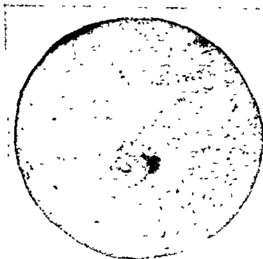


*Figure 221.* Endoscopic appearance of small sessile polyp.



*Figure 222.* Pedunculated polyp with granular surface.

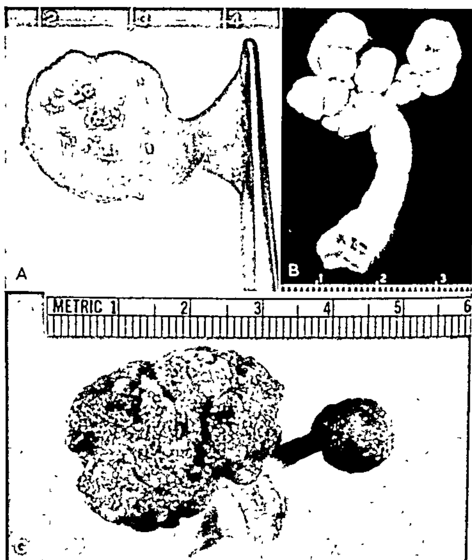



*Figure 223.* Varieties of pedunculated, lobulated polyps.

forceps and the base fulgurated with a Bovie electrical surgical unit. In larger sessile polyps excision by multiple biopsies is followed by fulguration of the remaining fragments and base. Extreme care should be exercised in fulgurating polyps on the anterior rectal wall and above the peritoneal reflection in order to avoid perforation of the thin intestine. Only experience can teach one the degree of fulguration needed to destroy a polyp; however, if one uses discretion and realizes that the depth of tissue destruction is always greater than it appears, perforation can be avoided. Proctoscopy after ten days will indicate whether the initial procedure was adequate; if it was not, fulguration can be repeated.

Bleeding is seldom a problem and usually can be controlled by gently pressing a cotton applicator on the bleeding point for 2 to 3 minutes. In rare instances a cotton applicator soaked in epinephrine and tannic acid will arrest bleeding. It is best to control active bleeding before fulguration because the degree of tissue destruction can be more accurately evaluated in a dry field. At times fulguration is the only method that will control brisk bleeding and should certainly be employed if the more conservative methods have been unsuccessful. Delayed bleeding, though rare, may occur when the slough takes place in 5 to 7 days.

Pedunculated polyps must be submitted in their entirety to the pathologist, because multiple biopsies from the periphery of the lesion are not sufficient for accurate diagnosis. Fifteen per cent of polyps that appear benign on clinical inspection are found to have malignant

changes. The polyp is removed by fulgurating the pedicle where it joins the polyp. By manipulation of the polyp the entire surface of the pedicle can be thoroughly fulgurated and the polyp detached from the charred pedicle *in toto* without bleeding. Pedunculated polyps can be easily excised with the electrocoagulating snare. Caution must be exercised not to sever the pedicle too quickly, for inadequate coagulation of the large artery traversing the pedicle can cause troublesome bleeding.

In low-lying pedunculated polyps the tumor can frequently be prolapsed through the anus to permit application of two forceps across the pedicle. The pedicle must be severed, leaving a cuff of tissue protruding from the clamp still attached to the intestinal side of the pedicle, to avoid retraction of the pedicle artery that can cause extensive submucosal hematoma or active bleeding. Hemostasis of the pedicle can be secured with a transfixation suture of 000 chromic catgut.

If the final pathologic diagnosis is benign adenoma, benign adenoma with atypism, or carcinoma *in situ*, no further surgical treatment is necessary. If the final diagnosis is invasive carcinoma, however, radical excision must be performed, the type of procedure depending on the location of the lesion.

Postoperative treatment consists in low residue diet for 10 days and avoidance of constipation by use of mineral oil. Strenuous exercise should be avoided. Most patients are ambulatory. Patients who had transproctoscopic removal of large polyps above the peritoneal reflection should be confined to bed for about 10 days.

*Papillary or villous adenomas*[11] are rare, usually solitary neoplasms, occurring in the older age group. Most of them are located in the mid-section of the rectum. Papillary adenomas are flat with a papillary or a combined papillary and lobulated surface (Fig. 224). The soft consistency of the tumor feels like normal tissue, and it is often impossible to detect even large lesions by palpation. Induration in a villous tumor means probable malignant change. Unlike adenomatous polyps, the growths are usually large when detected. They range in size from 2 cm. to more than 13 cm. They are attached to the intestine by a broad base and inspection reveals a velvety papillary mucosa or a combined papillary lobulated surface. The color is pink to red, being just a little darker than normal mucosa. At times the lesion is dark red. Pedunculated villous adenomas are sometimes noted.

*Treatment.* Because of the high incidence of malignant changes, multiple biopsies for histologic diagnosis should be done before definitive treatment is begun. In the smaller benign lesions thorough fulguration is adequate. For




Fig. 224. Villous adenomas are usually flat with a papillary surface.

lesions below the peritoneal reflection fulguration can be accomplished in one stage. For those above the peritoneal reflection fulguration may have to be done in multiple stages. In low-lying lesions it is best to excise the tumor and ligate the base with 000 chromic catgut. Local excision can often be accomplished with the cautery snare. If the mucosal surface is extensively involved, a more radical procedure, such as anterior resection or "pull-through" proctectomy with preservation of the sphincter, is necessary. For patients with invasive carcinoma combined abdominoperineal resection of the rectum and sigmoid is mandatory. All procedures except fulguration of a small tumor are major operations requiring hospitalization.

After fulguration of these large villous polyps a low residue diet should be employed for 10 days. Confinement in bed or restricted activity for the same period of time is recommended for all patients with lesions above the peritoneal reflection. Patients with smaller lesions below the peritoneal reflection may be ambulatory. Bowel movements should be regulated with mineral oil.

*Carcinoids*[12–14] are rare, low grade, submucosal, malignant neoplasms resembling polyps. They frequently project into the intestines. They are usually located in the lower rectum and in most instances are palpable. They have a hard, "shotty" consistency, are freely movable and are discrete. They are generally small, measuring 0.5 to 1.5 cm. in diameter. The rectal mucosa covering the lesion is thin and the vascular pattern can be seen. The tumors are orange, yellow or grayish in color and are round or oval in shape (Fig. 225). Lesions that are ulcerated or associated with induration or adjacent tissue generally signify malignant extension, and the possibility of metastases is likely. In some cases carcinoid tumors completely encircle the intestines to cause obstructive symptoms. Mucosal ulceration occurs late.

*Treatment.* Because of the clinically benign behavior of small rectal carcinoids, abdominoperineal resection is not recommended. Low-lying lesions are best treated by surgical excision with ligation of the base. In other instances the tumor may be excised by multiple biopsies followed by deep electrocoagulation of the base. Owing to the fibrotic consistency of these tumors, they are hard to cut and occasionally are enucleated from their attachment intact. Fortunately, most carcinoids are located in the lower rectum and can be fulgurated with impunity.

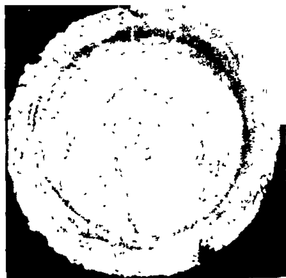


*Figure 225.* Typical endoscopic appearance of preinvasive submucosal carcinoid neoplasm; round, smooth, yellowish, firm and movable.

***Other Polypoid Lesions.*** Inflammatory polyps resemble true benign adenomas. They are more vascular and may bleed more freely on biopsy. At times the polyp may have a hemorrhagic or dark red color. The diagnosis is confirmed by histologic study and treatment is the same as for benign adenoma.

Heredofamilial or diffuse polyposis of the colon is a disease of the young. The average age is about 20 years. Treatment is a surgical procedure requiring hospitalization.

Multiple polyps of the colon are frequently encountered and must be differentiated from diffuse heredofamilial polyposis, for their treatment is more conservative. The final decision in the management is at times most perplexing even for the most experienced surgeon.

Submucosal lipoma, submucosal fi-

broma, submucosal hemangioma and lymphangioma constitute the rarer types of tumors found in the rectum.

Benign lymphomas[15] are also rare submucosal lesions which may resemble a benign adenomatous polyp. They are usually located in the lower portion of the rectum and are more readily palpable than visualized. They are of firmer consistency than polyps but they are not as hard as carcinoids. They are freely movable. The mucosa over the tumor is intact.

*Treatment.* Since benign lymphomas of the rectum are not premalignant, they can be treated by total surgical excision or by biopsy and fulguration.

### CANCER OF THE RECTUM[16-17] AND COLON, AND HEMORRHAGE

Carcinoma of the rectum and colon, like malignant neoplasm of other organs, grows silently. Clinical manifestations appear only after ulceration, obstruction, infiltration or metastasis develops. Bright red rectal bleeding denotes pathologic alterations in the colon or anorectum. Too frequently, this is an important ominous sign of cancer which is interpreted by the patient as well as by many physicians as being caused by hemorrhoids. It is not uncommon to see patients with carcinoma of the rectum or colon in whom rectal bleeding was previously treated either by hemorrhoidectomy or injection without the benefits of a digital rectal examination. The bleeding from carcinoma is usually not profuse; at times only blood-streaked mucus is observed on the surface or mixed in the stool. It is true that most bleeding is of anorectal origin, and is caused by hemorrhoids or fissures. Bleeding from polyps resembles that from carcinoma and only rarely is the amount profuse. When anoscopy and proctoscopy reveal an anal fissure, hemorrhoids or polyps in the rectum or sigmoid as probable sources of rectal bleeding, it must be realized that examination is not complete until barium enema and barium and air double contrast roentgenographic studies of the colon have been done to be certain that there is no concomitant disease above the proctoscopic level.

Bright red bleeding may occur from many other diseases, such as diverticulitis, chronic ulcerative colitis, factitial proctitis, bacillary dysentery, amebiasis, heredofamilial diffuse polyposes, heman-

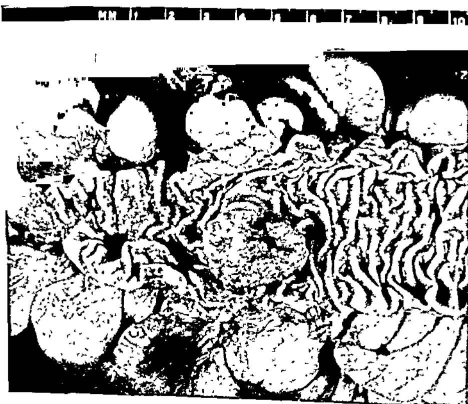


*Figure 226.* Early nodular carcinoma.



*Figure 227.* Early ulcerated carcinoma with typical elevated rolled edges at periphery of lesion

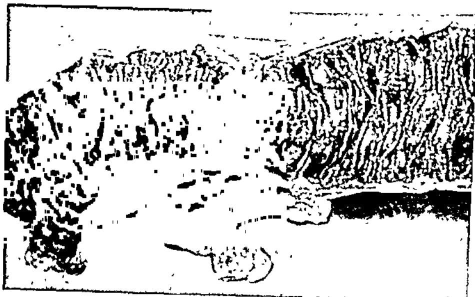


*Figure 228.* Constricting (napkin ring type) carcinoma of lower sigmoid with melanosis coli.

gioma, Meckel's diverticulum or traumatic injuries. Dark blood or tarry stool usually signifies bleeding from the upper gastrointestinal tract.

Carcinoma of the rectum and colon is the fourth most frequent malignant tumor in the female and second only to carcinoma of the stomach in the male. The high incidence of accurate diagnosis and good surgical prognosis in early cases makes it obligatory always to consider cancer of the rectum and to perform an adequate physical examination. In carcinoma of the colon the tumor is palpable in over 60 per cent of the patients and is visible on proctosigmoidoscopic examination in 80 per cent of the cases.

The palpable characteristics and endoscopic appearance of carcinoma depend entirely on the type and stage of the disease. Early in its development the lesion is an indurated, nonulcerated, round or oval growth (Fig. 226). The surface is nodular or smooth. The lesion is attached to the intestine but not fixed to adjacent tissue. Some early cancers are ulcerative lesions with raised indurated rolled edges about the periphery (Fig. 227). In later stages most lesions infiltrate the intestinal wall in a circumferential fashion, resulting in ultimate complete intestinal obstruction

(Fig. 228). During this stage the surface of the lesion becomes deeply ulcerated, bleeds, and at times shows superficial grayish necrosis. On endoscopic examination the raised indurated edge that lips the periphery of the tumor is diagnostic. The surface is granular and may be lobulated. The color is dark pink to red. A definite diagnosis of carcinoma is easily confirmed by obtaining biopsy fragments with any suitable biopsy forceps and immediately placing the pieces of tissue in a 10 per cent solution of Formalin before sending the specimen to the laboratory for histologic study.

### HEMORRHOIDS[15]

Hemorrhoids are varicosities involving one or more radicals of the hemorrhoidal plexus of veins. Many etiologic factors are responsible for their development. Among the most important predisposing causes are gravity action in an erect position, strain of heavy lifting, straining at stool, increased venous pressure in the hemorrhoidal plexus from intra-abdominal tumors, pregnancy, cardiac failure, cirrhosis of the liver, and infection in the crypts of Morgagni with phlebitis resulting in weakening of the veins. Hemorrhoids may be classified topographically as external or internal. External hemorrhoids are those situated below the pectinate line, covered by anal skin, always detected by inspection and not reducible. Internal hemorrhoids are located above the pectinate line and are covered by rectal mucous membrane. Since they are inside the rectum, they are visible only by endoscopic examination unless they are large or the supportive structure is redundant enough to permit protrusion into the anal canal below the level of the pectinate line.

Uncomplicated internal hemorrhoids may be further classified into four groups as to their anatomic location in relation to the pectinate line. These types have been designated according to their severity as first, second, third and fourth degree.

First degree internal hemorrhoids are varicose and dilated veins, which although prominent during anoscopic examination, at no time protrude below the pectinate line.

Second degree internal hemorrhoids are varicose and dilated veins which protrude into the anal canal below the pectinate line when the patient strains on physical exertion. However, upon cessation of straining the protruding hemorrhoids will spontaneously retract into the rectum and remain above the pectinate level.

Third degree internal hemorrhoids will protrude into the anal canal below the pectinate line during some straining but remain prolapsed after cessation of straining, necessitating manipulation to replace them into the rectum.

Fourth degree internal hemorrhoids protrude into the anal canal below the pectinate line upon minimal straining and remain prolapsed most of the time in spite of repeated manual reduction. Repeated prolapsing of the hemorrhoid reduces the tone of the sphincter ani and such straining as produced by standing, sneezing or coughing may be sufficient to cause them to prolapse. The actual size of the hemorrhoid is of little significance from the standpoint of prognosis and treatment, whereas the anatomic location and behavior in regard to the level of the pectinate line are extremely important.

*External Hemorrhoids.* Uncomplicated external hemorrhoids are generally asymptomatic but may cause anal itching. Most patients complain only of a lump or tag which makes anal hygiene difficult.

In acute thrombotic external hemorrhoid, the blood clots and the vein is greatly distended. The usual signs of acute inflammation are present. Although usually only one external hemorrhoid is involved, it is not uncommon to have multiple thrombotic hemorrhoids. The usual history is that the patient had an "attack of piles" associated with some physical effort or at times appearing spontaneously. The pain is sudden, constant, increasing in severity during the first 24 to 72 hours, and often incapacitating. During this phase

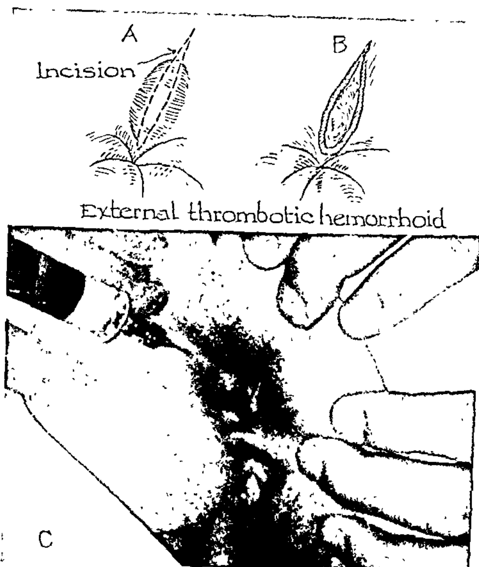



*Figure 229.* Enucleation of thrombotic external hemorrhoid. *A,* After local anesthetization the skin over the hemorrhoid is elliptically excised. *B,* Blood clots are extracted with forceps and wound is left open. *C,* Injection of procaine.

inspection will reveal a globular, bluish or purplish, firm, exquisitely tender mass, varying in size from ⅛ to ¼ inch in diameter, projecting above the skin level of the anus.

*Treatment.* If the patient is seen after 48 or 72 hours, he will probably be feeling better. In such cases treatment may be conservative, consisting of administration of ¼ to ½ grain of codeine sulfate with 10 grains of aspirin, rest in bed, hot or cold compresses to the anus, oral administration of liquid petrolatum, hot sitz baths and local application of analgesic ointment. The clot of blood will be absorbed in about 6 to 10 weeks and sometimes a small skin tag remains at the site.

In the acute painful stage a minor surgical procedure, which can be performed in the office, affords excellent relief (Fig. 229 *A*-*C*). With the patient in the lateral Sims position the anal area is gently cleansed with soap, water and cotton, and painted with an antiseptic solution of Zephiran or Merthiolate. Local anesthesia is induced by infiltration with 1 per cent solution of procaine. To minimize the discomfort, pure phenol solution is applied just lateral to the margin of the hemorrhoid and after a few seconds the fine hypodermic needle is inserted through the anesthetized area. Intradermal infiltration over the surface of the hemorrhoid or between the skin and the hemorrhoid is then carried out. The needle is then directed beneath the hemorrhoid in the midline and then on

each side in a fanlike manner. Only 2 to 3 cc. of procaine is needed. With a sharp scalpel, to avoid pressure, an elliptical incision radiating from the anal orifice is made over the raised surface of the hemorrhoid. Excision of the skin actually unroofs the hemorrhoid and permits complete evacuation of the soft dark clot. If the clot is stuck to the intima, it is best to extract it with a hemostat or plain tissue forceps, for squeezing about the hemorrhoid causes unnecessary pain and is not as efficacious in removing the entire clot with its adherent ramifications. Bleeding is not usually a problem and can be easily controlled with pressure, 000 plain catgut, electrocoagulation, or a small Gelfoam or Oxycel pack. The wound is left open.

Complete excision, which is preferred by some, can be accomplished by making an elliptical incision in a radial manner from the anal orifice about the margins of the hemorrhoid. The hemorrhoid is then grasped with a forceps, retracted and separated from the underlying tissue by sharp dissection with scalpel or scissors. The less radical procedure affords complete relief and is perferable to the excision methods, which require more time to heal. A simple surgical dressing applied with light pressure over the anus and held with adhesive is sufficient.

Postoperative management consists in bed rest for the first 12 to 24 hours, hot sitz baths three times a day or warm saline compresses to the anus, and avoidance of highly seasoned food. Constipation can be controlled by administration of a bulk laxative. Codeine (½ or ¼ grain) and aspirin (10 grains), though seldom needed, may be administered in the immediate postoperative period. Daily cleansing of the open wound with a mild antiseptic solution in the office will promote smooth healing in a few days.

*Internal Hemorrhoids.* Frequently, asymptomatic internal hemorrhoids are detected on routine anoscopy but require no treatment. Many of the symptomatic ones are best treated by conservative measures. This is particularly true during pregnancy and the immediate postpartal period, and in patients with hemophilia, thrombocytopenia, acute congestive heart failure and many other medical and surgical illnesses.

In the *conservative palliative management* of internal hemorrhoids the hemorrhoidal mass, if protruding, should be reduced by manipulation with the fingers before complications resulting from strangulation, such as thrombosis, ischemic ulceration, gangrene and infection develop. Measures should be instituted to prevent recurrence of prolapse and bleeding. If there is a tendency for the prolapse to recur, a bandage as described under strangulated hemorrhoids will be helpful (Fig. 232). Rest in bed in a prone position with a pillow under the hips and the foot of the bed elevated, and continuous hot saline compresses to the anus, will provide great comfort, especially if there is evidence of an inflammatory reaction. Good daily bowel elimination is essential and can be obtained by use of mineral oil or a bulk laxative. Low residue diet and elimination of highly seasoned food and alcohol are helpful. Application of an astringent analgesic ointment about the anus and in the rectum not only provides physical relief but also ameliorates the apprehension. Several days of such treatment will completely relieve the pain. It is advisable to continue the low residue diet and the bulk laxative for 4 to 6 additional weeks.

*Injection treatment* is today a recognized form of therapy for some cases of internal hemorrhoids, if the patients are discriminately selected and the surgeon is fully cognizant of the limitations of the procedure. A prerequisite for careful selection of patients for injection therapy is adequate knowledge of anorectal anatomy and pathology. Moreover, the technique of injection is not easy and must be meticulously performed for best results and minimal complications. The object of the injection is to instill in the submucous layer of the rectum a sclerosing solution that diffuses about the hemorrhoidal plexus of veins, pro-

moting a chemical inflammatory reaction with subsequent contractive fibrosis that obliterates the venous plexus and shrinks the vascular mass.

INDICATIONS. The ideal candidate for injection is the one with bleeding but otherwise uncomplicated minimal or first degree hemorrhoids, especially if the patient has only one primary hemorrhoid. Better results are obtained by surgical excision in patients with second, third or fourth degree internal hemorrhoids. However, occasionally, injection treatment may be recommended for such patients when operative treatment is contraindicated because of old age, mental condition, tuberculosis or other chronic illness. In such cases treatment is only palliative and recurrence within one to three years is likely. In young patients with an inherent tendency to the development of hemorrhoids, palliative injection treatment may prove sufficiently beneficial to postpone surgical treatment until middle age. Sometimes, patients will prefer injection treatment to the confining surgical procedure in order to permit them to fulfill important previous social or professional engagements. There is no doubt that in large charity clinics with a shortage of hospital beds, many patients can obtain relief by means of injection treatment without hospitalization. Another type of patient to whom injection treatment might be offered is the one who has undergone surgical excision for one primary hemorrhoid and in whom additional hemorrhoids later develop. Mild mucosal rectal prolapse is also frequently benefited by injection.

CONTRAINDICATIONS. Under no circumstances should external hemorrhoids be injected. Moreover, injection is not recommended for patients with acute or chronic prostatitis, fistula, fissure, ulcerated, thrombosed, strangulated or prolapsed internal hemorrhoids, or other anorectal disease. In some patients with second degree and in all of those with third and fourth degree internal hemorrhoids, the repeated prolapsing of the hemorrhoid below the pectinate line causes the rectal mucosal covering to become modified and the hemorrhoidal mass becomes thickened and fibrotic. Surgical extirpation is preferable in such cases. Patients with both internal and external hemorrhoids are also best treated surgically. Skin tags should not be injected.

TECHNIQUE. The instruments required for injecting hemorrhoids include a 3 cc. glass Luer-Lok syringe with finger rings, a long 25 gauge needle and any tubular anoscope. Quinine and urea hydrochloride in 5 per cent aqueous solution or a 5 per cent solution of phenol in clear vegetable oil, such as almond oil, may be used as the sclerosing solution.

The patient is placed in the left lateral Sims position or in the head-down jackknife position if a proctology examining table is available. The largest of the bleeding hemorrhoids is injected first. If the hemorrhoids are about the same in size and behavior, it is best to inject only one at the time of initial treatment. Only those with considerable experience with injection treatment should inject more than one hemorrhoid during an initial treatment. The anoscope should be inserted deeply into the rectum and then carefully withdrawn until the most proximal portion of the hemorrhoid or the pedicle of the hemorrhoid comes into view. The injection should be made in the pedicle and not into the body of the hemorrhoid (Fig. 230). Once the site of the injection has been determined, the mucosa should be swabbed clean and a dry antiseptic solution applied. The needle should be pushed through the thickness of the mucosa and permitted to slide into the loose areolar submucosal layer for several millimeters. The sclerosing solution should be slowly injected into the submucous layer; this results in a ballooning of the mucosa into the lumen of the rectum. The injection should be discontinued when the color of the mucosa changes from pink to a slightly ischemic pallor. The looseness and redundancy of the mucosa and the size of the hemorrhoid determine the quantity of scleros-

ing solution injected; usually this varies from 1 to 3 cc. and certain instances may require even more. More than one injection to instill the solution into the selected hemorrhoid is not recommended; the entire quantity of solution should be instilled through one injection. The appearance of a white spot at the site of injection immediately upon starting the injection means that the solution is being placed intramucosally. In such cases the needle must be pushed into the submucous layer or, preferably, it should be withdrawn and reinserted in a nearby normal area. Upon completion of the injection the anoscope and needle are withdrawn simultaneously. Immediate post-injection bleeding is usually no problem and can be readily controlled by pressure over the bleeding point with large cotton swabs. No special after-care is necessary except to limit strenuous physical exercise for 24 hours and to avoid constipation by administration of mineral oil.

Because of the entodermal embryonic origin of the rectum and its sympathetic nerve supply the injection should be painless. However, the rectum is not altogether insensitive, for when the solution is infiltrated into the submucous layer, the patient frequently complains of a sensation of distention or fullness in the rectum. This disappears once the solution disseminates in the submucous layer. It should be recalled that the anal canal below the pectinate line, including the anal valves, crypts and anal papillae, is of ectodermal embryonic origin with a sensory nerve supply from the inferior hemorrhoidal nerve, so that this area is extremely sensitive. Pain during or soon after an injection means the solution was infiltrated too close to the sensitive pectinate line. This is an error in technique that must be avoided. Under no circumstances should an injection be made for hemorrhoids that are in a "prolapsed" position. Protruding hemorrhoids must be replaced into the rectum to avoid the possibility of infiltration in or near the pectinate line due to distorted anatomic relations.

Injections should be done at 7 to 14 day intervals. The degree of chemical inflammatory reaction governs the treatment schedule. Repeating an injection into an area previously treated before the inflammatory reaction has subsided is not only difficult technically because of fibrotic fixation of the muscosa but is associated with greater incidence of slough. Mucosa that is fixed after injection should not receive additional injections.

COMPLICATIONS. Slough at the site of

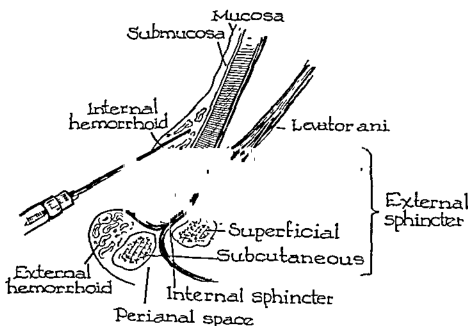



*Figure 230.* Diagrammatic illustration of the method of injecting sclerosing solution into the submucosa about the internal hemorrhoidal pedicle.




*Figure 231.* Subsiding strangulated internal hemorrhoids. *A,* Only left primary radicle involved *B,* All radicles involved.

injection is generally due to injecting too much solution, injecting the solution into the mucosa or repeating an injection into a site previously treated while the mucosa is still fixed to the submucous layer by residual inflammatory reaction. Secondary bleeding from ulceration due to slough is generally negligible; however, if bleeding is profuse, rest in bed and a rectal pack usually will suffice. Sloughs are to be avoided, for a secondary infection, proctitis, abscesses or fistulas may result. When ulceration does occur, the wound should be inspected once or twice a week and the surface cleansed with a mild antiseptic solution. The patient should remain on a low residue diet and avoid constipation by taking a bulk laxative. The wound will generally heal in several weeks.

Fibrotic tumefactions or oleomas about residual oil deposits have been reported when phenol and cottonseed oil were used but not when phenol and almond oil preparations were employed.[19] Allergic manifestations, such as erythema, tinnitus, vertigo, deafness, blindness and hoarseness, have been reported after use of urea hydrochloride in 0.2 to 0.8 per cent of cases. Stricture may result from extensive sloughs or coalescing oleomas.

Surgical excision of internal hemorrhoids is a major operation, to be performed in the hospital. Preoperative preparation should include a complete physical examination and sigmoidoscopy. Such laboratory examinations as complete blood count, urinalysis, serology and roentgenography of the chest should be done routinely. Electrocardiography, fluoroscopy and roentgenologic examinations of the colon by barium enema should be done on all patients over 40 years of age. Patients with a history of bleeding should have barium and air contrast enema roentgenologic study to rule out intrinsic colonic lesions, such as polyps or malignancy. The preoperative administration of 2 gm. of Sulfathalidine or other suitable chemotherapeutic agents every 6 hours for five days is an excellent adjunct in anorectal surgery.

*Strangulated Internal Hemorrhoids.* One radicle (Fig. 231*A*) or all primary hemorrhoidal radicles (Fig. 231*B*) may prolapse into the anal canal during extreme physical effort. Spasm of the external and internal sphincter muscles usually occurs and interferes with adequate return of the venous blood from the protruding internal hemorrhoid. This is soon followed by development of acute bulbous edema, measuring sometimes 3 or 4 inches in diameter. As pain increases so does the spasm, setting up a vicious cycle resulting in ischemia, thrombosis

and gangrene with actual slough of the hemorrhoid, and invariably some secondary infection results. The large, protruding, edematous mass is moist and weeping with mucus and serosanguineous transudation. The appearance of the internal strangulated hemorrhoids, of course, varies with the stage of ischemia or duration of the condition. The pain is excruciating.

*Treatment.* All hemorrhoids in the early or pregangrenous stage should be reduced into the rectum. The patient is given 1/6 to 1/4 grain of morphine sulfate, depending on the age, 30 to 45 minutes before he is placed in a prone position with hips elevated on a pillow. With a gloved hand the mass is gently held with the fingers and thumb (Fig. 232*A*). Gently and slowly, increasing pressure is applied, at first with the idea of compressing the edema out of the mass. Gradually, the slowly increasing pressure causes the sphincter muscles to relax so that the entire mass enters the rectum, leaving visible only a small area of edematous anal skin. This maneuver requires the utmost patience and takes 10 to 25 minutes. If no sudden or jerky movement is made, the procedure is well tolerated. Immediately after the hemorrhoidal mass has been reduced, a tight bandage should be applied. Multiple sponge gauze dressings should be packed against the anus (Fig. 232*B*), after which the buttocks should be pulled to the




*Figure 232.* Reduction of prolapsed internal hemorrhoids and rectum. *A*, Protruding mass is grasped with fingers and thumb; with gentle pressure the mass is replaced into rectum. *B*, Gauze is placed over anus after reduction. *C*, Dressing is held in place by pulling buttocks together with adhesive.

midline and held fast with a large adhesive dressing (Fig. 232C).

In apprehensive patients this procedure may be too painful without an anesthetic. In such cases the following procedure is helpful. A well lubricated finger is inserted into the rectum. With a fine hypodermic needle, a 1 per cent solution of procaine is injected about 2 inches from the anal verge and directed first to the sphincter muscles and to the right and left of the midline into the periphery of the sphincter muscles. The needle is then withdrawn and 5 cc. of a 5 per cent solution of Rectocaine or Nupercaine in oil is injected in a similar manner. The procedure is repeated anteriorly. After a short time, the reduction can be accomplished without pain.

If the patient is not seen until the advanced stages manifested by brawny edema, gangrene, slough and associated infection, he should be hospitalized for conservative palliative treatment. Surgical extirpation is contraindicated during the acute phase. Operation should be undertaken only after subsidence of all inflammatory signs, which usually requires from 6 to 10 weeks.

#### INFLAMMATORY DISEASE OF THE ANORECTUM

Cryptitis, anal fissure, para-anal or pararectal abscess and fistula-in-ano represent stages of an anorectal inflammatory process and should not be considered as separate diseases.

*Anatomy*. To comprehend the pathogenesis of anorectal inflammatory disease an understanding of anorectal embryology, physiology, and gross and microscopic anatomy is essential. About the seventh week of embryonic life the proctodeum of ectodermal origin perforates, thus connecting the anus to the lower rectum, which is of entodermal origin. The junction of the anal skin and rectal mucosa, known as the dentate line, pectinate line or mucocutaneous junction, forms the most important landmark in anorectal disease. In the lower rectum the mucosa assumes a characteristic pattern forming longitudinal rectal mucosal folds known as the columns of Morgagni. At the base of the columns of Morgagni the anal skin forms minute papillae. There are 6 to 8 anal papillae about the circumference. These are connected by a thin fold of sensitive modified squamous epithelium forming the anal valves. The cup-shaped spaces between the anal papillae, anal valve and rectal mucosa are the anal crypts of Morgagni. The apex or bottom of the crypts is connected to vestigial anal glands. The anal glands are usually located in the subepithelial areolar tissue of the pectin, that is, the upper third of the anal canal, but may extend through the sphincter muscles or to the submucous layer of the rectum.

*Pathogenesis*. Inflammatory disease of the anorectum starts by infectious material entering into one of the crypts of Morgagni, more frequently the posterior crypts. The infection is disseminated via the vestigial glands that are connected to the apex or bottom of the crypts or through the lymphatics. Most frequently a superficial subcutaneous infection is localized in the anal canal posteriorly. The skin sloughs and an anal ulcer or fissure is the result. Abscess with subsequent fistula about the anus and rectum is an occasional complication of an anal fissure or ulcer; the location of the abscess depends on the pathway of the dissemination (Fig. 233). Usually the perianal and ischioanal spaces and rarely the pelvirectal, submucous and retrorectal spaces are involved. Infection may extend from an anal crypt to the spaces mentioned via the vestigial anal glands or the lymphatics without the formation of an anal ulcer.

Infection of the para-anal and pararectal spaces results in an abscess that becomes progressively larger until it ruptures spontaneously internally or externally or is drained surgically. With drainage the abscess cavity shrinks and becomes a chronic inflammatory tube, a fistula which connects the site of origin of the infection in one of the anal crypts to the site of drainage.

Chronic anal fissures (ulcers) and fistula-in-ano can be permanently cured only by adequate surgical treatment. Conservative treatment or an inadequate

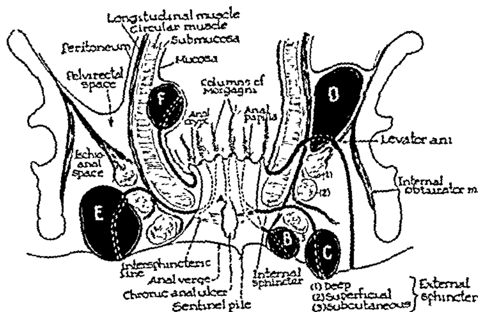



*Figure 233.* Diagrammatic illustration of pathogenesis of cryptitis, chronic anal ulcer, abscess and fistula-in-ano *A*, Chronic anal ulcer (fissure). *B*, Superficial para-anal abscess with resultant subcutaneous fistula. *C*, Deep para-anal abscess with fistulous tract passing between subcutaneous and superficial external anal sphincter (common type) *D*, Supralevator abscess in pelvirectal space with fistulous tract passing superior to entire sphincter mechanism. *E*, Ischioanal abscess with fistulous tract passing between deep and superficial external anal sphincter. *F*, Submucous abscess with resulting fistulous tract.

surgical procedure results in failure because the focus of infection, the primary opening or infected crypt, furnishes a continuously inexhaustible supply of infectious material that keeps the inflammatory process active. Conservative treatment is only palliative, or renders the infection temporarily quiescent in some instances and gives the patient a false sense of having been cured. During the periods of quiescence the secondary opening or ulcer may become completely epithelized and may appear healed. However, reactivation of the infection results in another abscess that ruptures through the initial secondary opening or in another area, forming multiple secondary openings. Fistula-in-ano usually has a single primary opening in a crypt but there may be multiple secondary openings During stages of quiescence the primary or secondary opening may be impossible to identify.

*Anal Cryptitis and Papillitis.* The anal crypts are usually the site of origin of most anorectal infections. Papillitis invariably accompanies cryptitis. Hypertrophy of anal papillae is the sequel of repeated infection. Papillae per se may vary in size from a few millimeters to a long slender projection 2 to 4 mm. wide. Some have large bases and others may become globular on the end. Most hypertrophied anal papillae cause no symptoms and need no treatment. Anal papillae, which are of ectodermal origin, are remnants of the anal plate forming the landmark of the junction of the proctodeum and the rectum, known as the anorectal, dentate or pectinate line. The papillae, which are located at the base of the columns of Morgagni, are joined together by thin semilunar folds known as anal valves. They are 6 to 8 in number. The papillae and the anal valves enclose the anal crypts.

Anal papillae are symptomatic during the acute phase of infection or after the papilla has enlarged sufficiently to prolapse into the grasp of the anal sphincter. Because of repeated trauma and infection the papillae may become fibrotic and enlarge as much as 2 inches in diameter; symptomatic papillae are usually about 4 by 13 by 15 mm. in size. They feel firm and appear pale or white and smooth unless a fibromatous polyp has developed on the end. Sometimes the inexperienced examiner will diagnose a hypertrophied anal papilla as a rectal

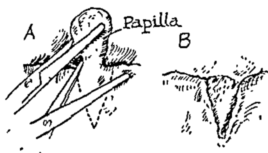



*Figure 234.* *A*, Hypertrophied anal papilla is either snipped off with scissors or elliptically excised at base *B*, Wound is left open.

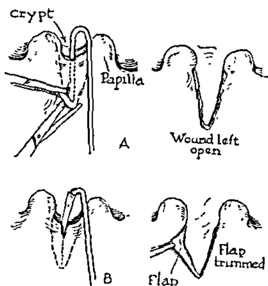



*Figure 235.* Surgical management of anal crypt. *A*, With the anal crypt outlined with a "crypt hook" the crypt is snipped off with scissors or excised with a scalpel, wound is left open. *B*, Anal valve is easily incised with a crypt knife and edges are trimmed

polyp on digital examination. The correct diagnosis can be made only upon anoscopic examination.

*Treatment.* Hypertrophied anal papillae are usually excised in the hospital because of their frequent association with other anorectal diseases. However, if the papilla is the only anorectal pathologic condition present, it may be excised in the office. An operating anoscope is inserted into the rectum, and upon removal of the obturator the papilla will fall into view. The area is swabbed dry with cotton, and a mild antiseptic solution is applied. With a 25 gauge hypodermic needle several cubic centimeters of a 1 per cent solution of procaine is inserted under the base and adjacent tissue. The papilla is grasped with a forceps, held taut and snipped off at its base with a scissors or by an elliptical incision about the base with a scalpel (Fig. 234). Papillae are vascular structures and bleeding is controlled by crushing with a forceps or by ligating with 000 plain catgut if necessary. The wound is left open. Next to the hypertrophied anal papilla the anal crypt will usually be found to be deep when examined with a crypt hook. By grasping its apex over the tip of the crypt hook and by simple traction the outline of the crypt can be ascertained and it can be snipped off with a scissors or excised with a scalpel (Fig. 235*A*). When infected crypts are unassociated with hypertrophied anal papillae, the anal valve may be incised with a special crypt knife (Fig. 235*B*) and the edges excised with scissors. The wound is left open.

*Anal Fissure (Ulcer).* Anal fissure is usually referred to as a crack in the anal skin; however, it is more correct to consider this condition as a chronic anal ulcer or as a superficial subcutaneous fistula with primary opening in the crypt and secondary opening at the ulcer site. Rarely is a true fistulous connection detected grossly on clinical examination. The diagnosis of acute anal fissure should always be suspected when a patient gives a history of pain during and after defecation. The severity and duration vary, but usually the pain is severe, seemingly out of proportion to the small, insignificant-appearing anal lesion often overlooked in a cursory examination. The pain is due to the location of the ulcer in the sensitive anal canal and its associated severe anal sphincter spasm. The presence of small amounts of blood on the surface of the stool or toilet tissue is common. Retraction of the buttocks will reveal the anal fissure to be located posteriorly in the majority of cases. The lesion is best inspected by anoscopy. The defect is irregularly oval shaped with the greatest diameter in the longitudinal axis of the anal canal. The edges are undermined and there may be subcutaneous pocketing below the inferior angle with a teatlike swelling of the skin due to chronic lymphedema, known as

a sentinel pile. Proximally, there is usually 3 to 4 mm. of normal skin separating the ulcer from the dentate line. The anal papilla just above the ulcer is enlarged because of the chronic infection. The base of the ulcer lies directly over the subcutaneous portion of the external sphincter, and the muscle fibers are frequently visible. In chronic anal ulcer the pain and sensitiveness are negligible. In quiescent anal ulcers the external scar may appear minimal, but palpation may reveal varied degrees of residual fibrosis in the anal canal. Palpation enables better evaluation of the extent and depth of the inflammatory process (Fig. 210).

In acute fissures the pain is so severe at times that adequate examination is possible only with use of a local anesthetic, and in some nervous patients it is better to perform the examination with use of a caudal or low spinal anesthetic in the hospital.

Complications of anal ulcers are often caused by fear of pain during defecation. The patient postpones the act of defecation, which predisposes to constipation for which he takes mineral oil and mild laxatives. The soft stools fail to dilate the anal canal and the anal ulcer or secondary opening of the subcutaneous fistula fails to drain adequately. This predisposes to an increase in the infection, with inflammatory fibrosis (pectinosis) with ultimate anal stenosis. In some cases the infection is disseminated to involve the submucous, ischioanal, perianal, pelvirectal and retrorectal spaces, resulting in fistula-in-ano. Intersphincteric postanal collar-button abscess and anal sinus are frequent complications. Figure 233 is a diagrammatic representation of the location and stage of the infectious activity.

*Treatment.* The treatment of anal ulcer is surgical. However, the rare anal ulcers which occur in children occasionally heal with conservative management, such as dilation of the anal canal twice a day with the index finger, hot sitz baths three to four times a day for 20 minutes, low residue diet, bulk laxative, local analgesic rectal ointment and in rare instances some mild sedation or analgesic medication.

In acute anal ulcer of short duration in adults, palliation, and at times cure, may be obtained by injection treatment in the office. The patient is placed in the lateral position and the anal area is prepared with Zephiran. The left index finger is inserted into the rectum and acts as a guide (Fig. 236). With a 1 per cent solution of procaine in a 10 cc. Luer-Lok syringe with a small 25 gauge needle 5 cm. long, a small intradermal wheal is made 5 cm. posterior to the ulcer. The needle is then directed into the subcutaneous external sphincter under the ulcer, care being exercised not to get close to the inflammatory process; 3 cc. of the solution is then injected. The needle is withdrawn to the level of the skin and is reinserted into the posterolateral portion of the sphincter on the right side and again on the left side. After the procaine solution has been injected Nupercaine or Rectocaine in oil is injected in the same areas by the same technique, 2 cc. being injected posteriorly and 1.5 cc. on each side. This gives the patient immediate relief and relaxes the sphincter. The anesthesia lasts 10 to 14 days. During this time an active conservative regimen should be followed, consisting in hot sitz baths, anal irrigations with witch hazel three times a day and a daily office visit to cleanse the ulcer mechanically with a

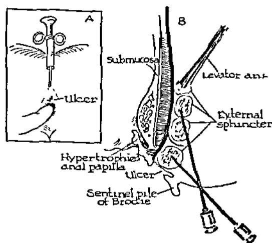



*Figure 236. A,* With the index finger in the rectum to act as a guide, the anesthetic solution is injected in a fanwise pattern. *B,* Direction of needle when instilling solution of procaine.

mild antiseptic solution. The anal canal should be kept dilated by the passage of large, formed stools induced by bulk laxative, which permits the ulcer to drain. Frequently the ulcers become quiescent and may at times be cured. This form of treatment is good in symptomatic chronic anal ulcer not associated with pectinosis when it is necessary to postpone definitive surgical treatment.

In chronic anal ulcer only adequate surgical excision of the entire pathologic process, performed in the hospital, can insure permanent cure. This includes removal of a triangular piece of tissue, with the base externally over the perianal skin, including the sentinel pile, adjacent perianal skin, ulcer and its base, anal papilla, crypts and, in the majority of cases, the posterior hemorrhoids, and severing the subcutaneous external sphincter bundle.

*Abscesses.* Perianal abscess is sudden in onset, extremely painful and associated with slight fever. Inspection reveals a small red swelling that is hot and exquisitely tender. These abscesses are located in the anal canal or near the anal verge. At times the abscess is rather deep in the postanal space and palpation is necessary to detect it.

Ischioanal abscess is of sudden onset, extremely painful and likewise associated with fever. The swelling is noticed between the anus and ischial tuberosity. Owing to the tenseness of the abscess cavity in perianal and ischioanal abscesses and to the exquisite tenderness, fluctuation is difficult to elicit.

In pelvirectal and retrorectal abscesses the spaces do not have sensory nerve supply and the rectal symptoms are vague or absent. The patient is usually acutely ill with sudden onset of fever, and at times has chills and is toxic. There may be no specific rectal complaint, only a feeling of fullness and heaviness. Urinary retention is a prominent symptom. The diagnosis is made by digital examination. On digital rectal examination a doughy fullness is felt encroaching on the rectum and there is pain on pressure over the abscess.

*Treatment.* Early adequate incision and drainage of all abscesses under a caudal or low spinal or general anesthetic in a hospital is the best method of management. Perianal abscesses that are superficial and fluctuant may be treated in the office with only slight discomfort to the patient (Fig. 237). The patient is first given a hypodermic injection of 1 grain of Luminal sodium. With a 5 cc. Luer-Lok syringe with a 25 gauge needle, a 1 per cent solution of procaine is injected intradermally directly over the abscess. With a sharp scalpel the abscess is drained by elliptically excising the skin covering the abscess. A small gauze pack or a drain is placed in the wound for 24 hours. The patient should take hot sitz baths three times a day and apply hot saline compresses in the interval between the baths. Daily visits should be made to the office for mechanical cleansing of the abscess cavity until healing from within outward is insured. Three to four weeks after drainage of the abscess, fistulectomy should be done.

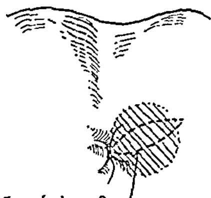



*Figure 237.* In superficial para-anal abscess, the cavity is unroofed by elliptically excising the skin over it.

*Fistula-in-Ano.*[18] The site of origin of a fistula is known as the primary opening, and the site of drainage of the abscess as the secondary opening. Because the site of origin is in the anal crypt in practically all cases, the term fistula-in-ano is the proper terminology. Sometimes an abscess drains spontaneously in a retrograde fashion through the crypt, leaving a chronic blind abscess pocket that is called an anal sinus.

Fistula-in-ano is diagnosed from a his-

tory of an abscess that was incised, or that ruptured spontaneously, with subsequent slight purulent drainage from the secondary opening. On examination the secondary opening may be found in the perianal region, the perineum, the vulva or the buttocks. By bidigital examination with the index finger in the rectum and thumb over the perianal skin the hard, fibrous, cordlike fistulous tract is generally palpable (Fig. 211). Anoscopy usually reveals the primary opening and it is most frequently in a posterior crypt. A probe should not be inserted into a fistula for diagnostic purposes, for this procedure is not only painful but the tortuous inflammatory tube may be punctured, thereby spreading the infection. Insertion of a flexible probe should be deferred until the time of the operation, when it can be more easily accomplished under anesthesia. Injection of Lipiodol or bismuth and petrolatum emulsion into the fistulous tract with roentgenographic study is an extremely valuable procedure in diagnosing a complex fistula-in-ano. Application of Goodsall's rule is helpful in determining the course of the fistulous tract (Fig. 238). In most fistulas the primary opening is in a posterior crypt and because the superficial sphincter has its origin from the coccyx and the anococcygeal body, most posterior abscesses are deflected to the right or left of the midline, causing the fistulous tract to have a curved course posteriorly. In the anterior half the fistulous tract is usually in a straight line.

*Treatment.* Fistula-in-ano varies from simple uncomplicated to complex involvement of the anorectal muscular mechanism and sometimes adjacent organs. Surgical treatment should be undertaken only in the hospital, with probably one exception: a short, superficial, subcutaneous fistula-in-ano, in which a fistulotomy can be accomplished in the office. With the patient in a suitable position, the anal area is prepared surgically before local anesthesia is induced by injection of a 1 per cent solution of procaine according to the same technique as described for acute anal fissure (Fig. 236). A probe is then placed through the fistula connecting the primary and secondary openings. A fistulotomy is done by incising the skin over the probe and excising the skin edges to enable granulation from the bottom (Fig. 239). Postoperative office treatment, such as separating the wound edges and swabbing with mild antiseptic solution to prevent bridging of skin edges, is most important.

*Anal Skin Tags.* Skin tags about the anus most frequently develop at the site of a previous thrombotic hemorrhoid, and at times are seen after hemorrhoidectomy. The redundant skin tag is mistaken for external hemorrhoids by patients. These patients usually consult a physician because of the presence of a protrusion about the anus, and at times

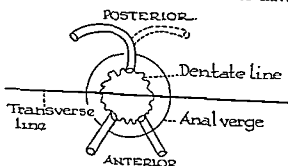



*Figure 238.* Goodsall's Rule—a transverse line divides fistula-in-ano into two groups: (1) When the secondary opening is anterior to a transverse line bisecting the anal canal into anterior and posterior halves, it is usually connected to the primary opening by a straight fistulous tract. (2) Secondary opening *posterior* to the transverse line is connected to a primary opening in the midline by a curved fistulous tract that may be horseshoe or semihorseshoe in pattern.

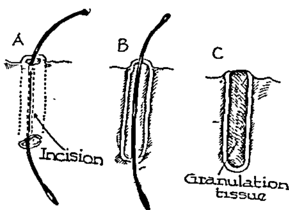



*Figure 239.* Fistulotomy for superficial subcutaneous fistula-in-ano. *A,* Skin incised over probe. *B,* Skin edges excised with scissors. *C,* Granulating wounds heal from within outward.

because of difficulty in maintaining good perianal hygiene. These tags are asymptomatic unless they become inflamed. The patient should be told that the skin tags are not hemorrhoids and require no treatment. However, for esthetic reasons many patients demand surgical excision; in other instances the mere presence of the tags continues to annoy the patient and interferes with cleansing of the parts so that surgical excision becomes necessary.

*Treatment.* With the patient in the lateral Sims position, the area is prepared by washing with soap and water, and tincture of Zephiran or Merthiolate is applied. One or 2 cc. of a 1 per cent solution of procaine hydrochloride is injected under the base of the tag, and the tag is excised by means of an elliptical incision radiating from the anal orifice. Bleeding is seldom a problem and can be easily controlled by pressure or plain catgut 000 ligatures. The wound is left open and covered with a surgical dressing. The postoperative management is the same as for thrombotic hemorrhoids.



*Figure 240. Perianal condylomata acuminata.*

### CONDYLOMATA ACUMINATA[20]

Condylomata acuminata, or venereal anal warts, are contagious, usually multiple, elongated growths about the anus that sometimes also involve the perineum, vagina and vulva (Fig. 240). The disease is caused by a filtrable ultramicroscopic virus. The elongated and elevated cutaneous growths frequently have a single base with a pedicle that branches into a cluster of multiple small villous papillary projections. Because of the warmth and moisture of the anal canal the warts may have a whitish macerated appearance; otherwise they are pink. Some lesions extend into the anal canal to involve the lower rectum. The clinical appearance of the multiple tuftlike nature of each tumor attached to a single broad pedicle is diagnostic. Condyloma latum of secondary syphilis is a flat lesion which may be diagnosed by a positive serologic reaction or dark-field examination.

*Treatment.* The old surgical excision under local anesthesia, using a technique similar to that for external skin tags, has been practically replaced with podophyllin treatment, which is specific. The latter treatment consists of washing the area with soap and water and, after drying, applying locally to the warts with a cotton applicator a 25 per cent suspension of podophyllin in mineral oil. After the solution has been applied, a small wad of cotton is placed at the anus to keep the skin separated in order to decrease local irritation to adjacent skin. Usually a single application suffices; the warts slough off, leaving no scar and causing no pain.

### PROLAPSE OF THE RECTUM[18]

In partial prolapse of the rectum only the mucosal layer protrudes from the anal canal (Fig. 241). In complete prolapse the protruding mass includes all layers of the rectum (Fig. 242). Partial rectal prolapse is a condition usually seen in infancy and early childhood and in old age. Whereas the history is suggestive, one must rely entirely upon examination of the protruding mass to establish the diagnosis and to determine the type of therapy required. In partial prolapse the mucosa protrudes from the anus about 2 to 3 cm.; seldom does the protrusion exceed 5 cm. The mucosal surface is

smooth and moist and the few longitudinal folds that are present radiate from the center of the anus. Palpation of the protruding mucosa between the index finger and thumb will demonstrate that only two thicknesses of mucosa are present.

In contrast, complete prolapse of the rectum, though extremely rare, occurs at all ages. The protruding mass is larger and occasionally extends many inches from the anus. The redundant mucosa covering the mass is thickened and hyperemic and is thrown into multiple circular folds. In recurrent prolapse the mucosa may ulcerate, and blood oozes from the surface during the prolapse. Palpation of the mass digitally with the index finger in the lumen and thumb on the outside wall reveals the thickness to be a double layer of all the layers of the rectum. In large prolapse, small intestinal herniation between the two anterior layers of the prolapse is present and compression will elicit a gurgling sound.

In both types if the protrusion is not replaced into the rectum, acute edema, ischemia, ulceration and gangrene may result. In patients with atonic sphincters these complications develop less frequently.

*Treatment.* In children who have a short history of prolapse and who are not malnourished or debilitated from some chronic illness, conservative nonsurgical treatment is usually satisfactory. The prolapse must be replaced into the rectum immediately. The patient should be placed in the lateral or knee-chest position. Dry cotton or soft gauze is placed over the mass and the entire mass is grasped between the four fingers and thumb at the apex or head of the prolapse. Gradual compression will squeeze the edema out while simultaneously the mass is gently pushed into the rectum. This maneuver must be done slowly; it may require from 5 to 15 minutes, depending on the size of the mass or the extent of edema. A ball of cotton or gauze should then be placed over the anus and the buttocks drawn together and held in position with adhesive (Fig. 232) or a suitable T binder; this is to prevent immediate recurrence of the protrusion before the muscles have regained their tone.

Re-education of bowel habit in these patients is important. The patient must be given mineral oil or some form of mild laxative that will regulate evacuation with a minimal straining effort. Prolonged straining prior to evacuation



*Figure 241.* Partial prolapse; only rectal mucosa involved.



*Figure 242.* Complete prolapse of rectum (procidentia); entire thickness of rectal wall involved

must be avoided. Placing of the patient in a recumbent position during the act of defecation is advisable, and actual support with the hands over the perianal area will prevent prolapse. General supportive measures, such as a well balanced diet, exercise and vitamins, will help to develop the muscular system and increase muscle tone. Phimosis, if present, should be corrected, for sometimes this is the factor initiating the prolonged straining effort. Proctitis, if present, must be treated.

The success of this nonsurgical regimen depends to a great extent on execution of the minor details and the patience and perseverance of the mother. Frequently weeks to months of patient management are necessary before satisfactory results are obtained.

If conservative treatment proves unsuccessful, submucous injection may be done in the office with satisfactory results in mild mucosal prolapse. Five per cent quinine-urea hydrochloride solution is a satisfactory sclerosing agent which may be injected in the submucosal layer according to the same technique as that for injection of internal hemorrhoids. One cubic centimeter of solution is injected into the anterior and posterior lateral walls on the right and left sides at the same level. The injection is made above the level of the hemorrhoidal pedicle (Fig. 230). Occasionally, one treatment will suffice; however, if necessary the injection may be repeated in a week or ten days at a different level. The conservative management is continued during the injection period until fibrosis of the submucous layer has caused sufficient fixation to cure the prolapse.

In the unsuccessfully treated partial prolapse and in complete prolapse in children the more radical perirectal alcohol injection treatment has produced satisfactory results and has practically replaced surgical treatment of prolapse in children. This treatment, as well as the surgical treatment of complete prolapse in adults, is a hospital procedure.

### RECTAL INJURIES AND FOREIGN BODIES

Lacerations of the rectal mucosa and submucosa may occur during insertion of a clinical thermometer or hard enema nozzle. These superficial injuries rarely require treatment, although at times active bleeding has to be controlled. This may be accomplished by direct pressure on the bleeding point. If the bleeding is persistent, clamping the bleeding point with a suitable forceps and electrocoagulation of the site or ligating with a suture may be necessary. In cases of infraperitoneal perforation the incidence of infection is high and prophylactic measures, such as streptomycin (0.5 gm.) and penicillin (400,000 units twice a day), are indicated. If an abscess develops, it should be drained. In patients with peritonitis a defunctioning colostomy should be established.

Perforation of the infraperitoneal portion of the rectum frequently results from ingested foreign bodies, such as toothpicks and fish, beef or chicken bones which become impacted in a transverse position near the anorectal junc-

tion. Pain and tenderness are prominent early symptoms. Since these wounds are usually associated with supralevator and para-anal infection and abscess formation, the patient should be given prophylactic treatment against infection. All abscesses should be immediately drained in the hospital. Because of the presence of infection it is much safer to use caudal or low spinal anesthesia to remove the foreign body; however, in early cases without infection a local anesthetic, with 1 per cent solution of procaine and the technique illustrated in Figure 236, is adequate if the fanwise pattern of instillation of the solution is applied anteriorly and posteriorly.

Rectal injuries resulting from an accidental fall on a picket fence or any sharp object are serious because impalement is generally associated with perforation, peritonitis and injury to adjacent organs. These patients require immediate hospitalization, abdominal exploration and, frequently, a defunctioning colostomy.

Innumerable types of foreign bodies, some as large as bottles and glasses, have been removed from the rectum. The large foreign bodies require regional anesthesia and occasionally abdominal exploration to enable removal.

### FECAL IMPACTION

Fecal impaction (coprostasis) may be defined as a large inspissated bolus of feces in the rectum that may extend proximally to involve the sigmoid and descending colon. It is not uncommon in diseases that produce severe constipation, such as congenital megacolon, rectal stricture or stenosis of inflammatory, neoplastic, postoperative or congenital origin. It can develop rapidly in patients who postpone bowel evacuation because of a painful anal ulcer or for other reasons. A change in bowel habits in elderly bedridden or physically inactive patients frequently leads to fecal impaction. Impaction is rare in children.

The early symptom of fecal impaction is constipation. A sensation of heaviness and fullness in the rectum, hypogastric colic pain from incomplete colonic obstruction, and unsuccessful attempts to defecate are common complaints. Later, there may be fecal incontinence or actual diarrhea with small quantities of liquid stool with each bowel movement. The passage of liquid feces between the inspissated bolus and the rectum is responsible for omission of a rectal digital examination and failure to recognize the presence of a fecal impaction.

On digital rectal examination the diagnosis is readily confirmed by palpating the hard impacted stool with a smooth surface. The shape is oval and the size may vary to involve the sigmoid and lower descending colon.

A soft fecal impaction is usually successfully eliminated with a saline enema. In more inspissated impactions, the lower portion should be partially broken with the tip of the examining finger; then 6 to 8 oz. of mineral oil is instilled and 2 hours later a saline enema is given. At bedtime 6 to 8 oz. of mineral oil should be instilled into the rectum and another saline enema given the following morning. The patient should then be reexamined and if the impaction is still present, the same routine should be continued daily until the rectum has been emptied. It is not necessarily urgent that the rectum be emptied at the time of the initial examination. There is certainly less discomfort and trauma to the patient to remove the impaction in two or three less vigorous treatments.

In some patients a vigorous attack must be instituted and the fecal mass removed piecemeal with the fingers. This is a long-drawn-out, tedious procedure and it is extremely important to take every precaution not to injure the rectal mucosa or tear the anal skin by overstretching the anal canal. Sometimes the procedure is so painful that it should be done in a hospital under caudal, low spinal or general anesthesia. Instruments to break fecal impactions may injure the rectum; they should be used with utmost care only when manual methods have failed.

Proctitis is frequently associated with chronic fecal impaction. In such cases

instillation of 3 to 4 oz. of warm olive oil may soothe the inflamed mucosa. Traumatic anal fissure is best treated conservatively. An anticonstipation regimen must be instituted if no organic basis for fecal impaction is found.

### PRURITUS ANI[21, 22]

Pruritus ani is a common complaint varying in severity from occasional annoying to continuous intractable perianal itching. The surfaces of the perineum, labia, scrotum and gluteal regions may become involved. The itching is frequently severe enough to produce irritability, nervousness and insomnia; at times it is intolerable. Itching is worse at night or when the patient is under undue nervous tension.

The appearance of the perianal skin depends on the severity and duration of the disease and the actual trauma produced by scratching. In the early cases the skin may be red and edematous and is thrown into longitudinal folds radiating from the center of the anus. There are frequent scattered areas of superficial excoriation, and the serous exudate covering the surface keeps the parts moist and at times macerated. Deep fissures between the swollen skin folds are sometimes present. In chronic cases the skin, because of repeated scratching, becomes thickened and leathery in appearance, and although redundant, is inelastic. Areas of hyperpigmentation and white blotches are not unusual.

Innumerable local anorectal, systemic and dermatologic diseases are specific etiologic factors in secondary pruritus ani. In many cases the etiology is obscured and the disease is considered primary. It is in this latter group that results of treatment are less satisfactory.

*Treatment.* The symptomatic treatment of pruritus ani cannot be condoned. Patients must be fully informed of the complexity of the disease and every effort must be made to find a specific etiologic factor. A complete history should be obtained with a sympathetic attitude and genuine interest in the patient's behalf. A thorough anorectal examination will usually exclude local disease such as hemorrhoids, prolapsed rectal mucosa, anal fissure, fistula-in-ano, condylomata acuminata, hypertrophic anal papilla, cryptitis, perianal furunculosis or congenital or acquired deformity. Fecal examination and culture studies will indicate the presence or absence of mycoses, amebiasis or other parasitic or infectious etiologic factors If results of these examinations are negative, a complete physical examination and necessary additional laboratory examinations are mandatory to rule out remote underlying causative factors such as diabetes, gout, obesity, hepatitis, neurodermatitis, neurogenic, allergic or anaphylactic factors, psoriasis, endocrine dysfunction or neurosis. Antibiotics, especially Aureomycin and Terramycin, may cause acute gastroenteritis with ulcerative colitis and, owing to alteration of the bacterial flora, may produce pruritus ani.

When dermatologic, systemic and anorectal conditions are the underlying cause of pruritus ani, treatment must be directed toward eradication of these diseases. In addition, a regimen of anal hygiene, sedation, diet and local applications should be employed. This routine care not only relieves secondary pruritus but gives symptomatic relief in a great percentage of patients with primary pruritus ani.

Meticulous anal hygiene is most important. Patients must take a bath or shower daily and at this time should wash the anal area with pHisoHex, which is an antibacterial sudsing fluid cream with a *p*H value of that of normal skin.[23] It contains no alcohol or soap, is hypoallergenic and more efficient as a detergent than soap. To minimize trauma and the scratch reflex, pHisoHex is used in the following manner. A few cubic centimeters are placed in the palm of the hands and briskly agitated to form a lather; then the anal and adjacent areas are thoroughly cleaned with the hands. The detergent is rinsed off and the skin is dried by blotting with cotton. It is not advisable to apply the detergent more than once daily or in full strength as a topical application. After each bowel

movement the anus should be cleansed with soft cotton saturated with water or witch hazel solution, and dried by blotting with cotton. At no time should the patient rub or scratch the area. Regular toilet tissue and bath towels frequently initiate intense itching and must not be used. Soap should not be used.

Most patients with pruritus ani seek treatment after all home remedies have failed. The "home treatment" is frequently overtreatment, resulting in ulceration of the skin from chemical injury or allergic reactions which are usually made worse by associated secondary infection. The damage to the skin in pruritus is in large part due not only to the trauma from scratching but also to the indiscriminate use of local medications.

In patients with extensive damage to the skin and secondary infection, boric acid compresses or potassium permanganate compresses may be applied. In some cases anesthetic solution may be used. Anesthetic ointment preparations afford minimal relief and too frequently cause sensitivity or chemical irritation. For these reasons they should not be used in the routine care of these patients. Lotions and powder give better results. Routinely, unmedicated talcum powder should be applied after each anal toilet. Burow's lotion is soothing for acute skin irritation. Calamine lotion may also be helpful. Alexander and Manheim[24] have reported excellent results with topical applications of 2.5 per cent hydrocortisone acetate ointment three times a day.

Phenobarbital two or three times a day will help alleviate nervousness and at times sedatives may be necessary at bedtime for insomnia until symptoms have improved.

All highly seasoned foods, alcoholic beverages, seeds and nuts should be omitted from the diet and in allergic patients the specific foods to which they are allergic must be omitted.

In many patients with primary pruritus ani this routine hygienic care will prove unsatisfactory. Other forms of treatment which may be tried are alcoholic injection, injection of long-acting anesthetic agents or undercutting of the perianal skin. These are not without danger, however, and must be resorted to only when absolutely necessary. They usually should be employed only in hospitalized patients. Roentgen-ray irradiation does not usually give permanent results.

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*Part V*

# Peripheral Vascular Diseases

*Chapter 18*

# Arterial Diseases

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Peripheral vascular disease is a rather inclusive term which through medical usage has been generally accepted and applied broadly to all forms of diseases of the blood vessels distal to the heart, particularly those of the extremities. It usually signifies a disturbance or actual diminution in the normal amount of circulating blood to a part, resulting in general from certain structural changes in the vessels, from functional disturbances or from a combination of these abnormalities. The term includes a number of diseases, of which some are well defined clinical and pathologic entities and others can be considered only as syndromes.

Various classifications of peripheral vascular disease have been proposed but none is entirely satisfactory, owing principally to the fact that the etiology of most of these conditions is not known. Perhaps the most convenient and useful classification, based largely upon anatomic and physiologic considerations, is that prepared by the Nomenclature Committee of the Section for the Study of Peripheral Circulation of the American Heart Association. Major divisions of this classification consist of diseases of arteries, veins, lymph vessels, minute vessels, and tumors With minor modifications this is the classification followed in this section, which is devoted chiefly to a consideration of the more common and important peripheral vascular conditions. For a more comprehensive consideration of the subject the selected list of references provided at the end of this chapter may be consulted.

In general, diseases of arteries and arterioles may be divided into two major groups, those characterized by functional or vasomotor disturbances and those having organic or structural changes. Depending upon the type and stage of the process, both of these factors may be present in many of the conditions but one or the other is usually predominant and constitutes the primary disturbance. Each of these major groups may be subdivided into two sub-groups. Thus, the functional conditions may be classified into those manifesting vasoconstriction primarily, represented by Raynaud's phenomenon, and those evincing vasodilatation, such as erythromelalgia. The organic conditions may be divided into occlusive diseases, such as arteriosclerosis obliterans and thromboangiitis obliterans, and nonocclusive disturbances, such as aneurysms and arteriovenous fistulas

## RAYNAUD'S PHENOMENON[1-11]

Although vasospastic changes in the extremities on exposure to cold had been observed earlier, it remained for Maurice Raynaud in 1862[8, 9] to give the first clear description of the disease which is known today as "Raynaud's phenomenon" Because it has since been demonstrated that these disturbances may also occur in association with a number of vascular diseases, it is now generally considered desirable to differentiate the condition into primary and secondary forms. Accordingly, the more descriptive term Raynaud's phenomenon is now preferably used in an inclusive manner to designate the syndrome, whereas the term Raynaud's disease is better applied to the primary or idiopathic form of the disease.

### Primary Raynaud's Phenomenon (Raynaud's Disease)

***Etiology.*** The actual cause of this disease remains unknown, although certain

factors seem to contribute to its development. It occurs predominantly in young women, the ratio of females to males being about 4:1. It also tends to develop at a relatively early age, most frequently during the second and third decades. Other factors which seem to be related to the development of the condition are inherent and include particularly heredity, endocrine dysfunction and nervous instability. In connection with the last, emotional disturbances such as anger, fear or excitement often precipitate the attacks. The principal factor, however, in producing the manifestations is cold.

*Pathologic Physiology.* The major disturbances in blood flow occur in the digital arterioles, with probably secondary changes in the capillaries and venules. The initial manifestation of pallor of the digits on exposure to cold or under conditions of emotional stress is probably due to spasm of the arterioles. During this stage the capillaries are relatively empty of blood. The pallor is usually followed, after a short time, by cyanosis, which is indicative of stagnation of blood in the capillaries. This is believed to be due to reflex filling of the capillaries by seepage of oxygenated blood from the venules. Intermittent leakage, probably due, as Lewis suggested, to temporary relaxation of arteriolar spasm, may occur, producing transient red spots which are soon replaced by a cyanotic hue. With cessation of the attack this stage is followed by dilatation of the arterioles, resulting in rapid filling of the capillaries with oxygenated blood which produces redness of the part and a tingling burning sensation; this probably represents a form of reactive hyperemia due to local accumulation of metabolites during asphyxia of the tissues. In the early stages of the disease there are no major pathologic changes in the vessels. Later, however, there may be intimal thickening and fibrosis, with hypertrophy of the media and narrowing of the lumen of the digital arteries and arterioles. In long standing cases the endo-arteritis may be severe and is often associated with organizing thrombosis of the arterioles.

*Clinical Manifestations.* Typically, the initial attack follows exposure to cold, the tips of the fingers first turning white, then blue and finally red. These color changes are accompanied initially by a numb sensation, followed by a tingling, burning or stinging pain. In the early stages of the disease, involvement may be unilateral and limited to the tip of one finger, but later the color changes may extend upward to involve the entire finger and even part of the hand. As the disease advances, other fingers become affected with a tendency towards bilateral symmetric involvement and swelling of the fingers. The symptoms usually subside rapidly when the part is warmed. In the early stages examination reveals little or no evidence of any vascular abnormality, but exposure of the hands to cold will usually produce the characteristic color changes. In advanced cases sclerodermatous changes may appear on the fingers and interfere with normal function of the part. In these late stages there may appear on the tips of the fingers painful, gangrenous ulcerations which tend to heal slowly, leaving telltale stellate scars.

*Diagnosis.* The diagnosis of Raynaud's disease should be restricted to patients with Raynaud's phenomenon without evidence of secondary cause. Accordingly, it may be established on the basis of a history, extending usually over a period of a few years or more, of episodic attacks of the characteristic color changes in the digits precipitated by exposure to cold or emotional crises, bilateral and usually symmetric involvement, and absent or minimal degrees of cutaneous gangrene.

*Treatment.* This is dependent upon the degree and stage of involvement. Simple conservative measures may be adequate in the early mild forms of this disease, whereas sympathectomy may be indicated in the more severe, progressive types.

In the majority of patients, symptoms can be controlled reasonably well by properly employed conservative measures, including particularly reassurance of the patient and avoidance of factors that produce vasospasm, such as cold,

emotional excitement and tobacco. Because most of these patients have a relatively unstable vasomotor status, they often manifest great anxiety concerning their condition. They should therefore be given an adequate understanding of the nature of the disease and reassurance that symptoms and progression of the condition may be controlled by proper treatment. They should also receive instructions concerning adequate protection against all precipitating factors, such as exposure to cold, nervous excitement and emotional crises. Warm clothing, including gloves, socks, shoes and ear muffs, should be worn in cold weather. A change of environment and a warmer climate should be sought, if possible. Various drugs have been employed in the treatment of this condition, but their value is questionable. In some instances certain adrenolytic agents, such as Priscoline, appear to provide temporary relief during aggravation of symptoms. If symptoms progress despite adequate prolonged trial of conservative measures, sympathectomy is indicated.

### Secondary Raynaud's Phenomenon

As indicated in the foregoing section, manifestations of Raynaud's phenomenon may be observed in a number of conditions, including occlusive arterial disease, post-traumatic states, neurogenic lesions and intoxication. Vasospastic disturbances may be associated with occlusive arterial disease of arteriosclerotic origin as well as that due to thromboangiitis obliterans, although they occur more commonly in the latter. Under these circumstances, the symptoms tend to be less striking and the cutaneous changes are more pronounced than those of true Raynaud's disease. There is also less likelihood of symmetric involvement. Moreover, pulsations are usually absent, providing convincing evidence of occlusive arterial disease.

Vasospastic disturbances occurring after certain forms of trauma are preferably termed "post-traumatic Raynaud's phenomenon." They may be related to occupation, as in the use of vibrating tools, for example, "pneumatic hammer disease." Post-traumatic Raynaud's phenomenon is also represented by the vasospastic disturbances associated with acute bone atrophy (Sudeck's atrophy, reflex dystrophy, painful osteoporosis). In some such instances, the injury is relatively mild, and the symptoms gradually develop over a period of weeks. In addition to the history of trauma and the characteristic roentgenologic osseous changes, an important feature distinguishing this from true Raynaud's disease is unilateral involvement.

Raynaud's phenomenon may also occur secondarily in association with various neurogenic lesions. In scalenus anticus syndrome, for example, with or without cervical rib, vascular symptoms may be pronounced, although most patients with this condition have symptoms referable to the brachial plexus. Circulatory disturbances with color changes suggesting Raynaud's phenomenon may also occur in a number of neurologic diseases, such as peripheral neuritis, syringomyelia, spina bifida, progressive muscular dystrophy and poliomyelitis. Vascular symptoms in most of these diseases are for the most part a consequence of disuse of the part rather than of any specific vascular lesion. With the ready demonstration of the underlying neurologic disturbance and of absence of any evidence of significant arterial insufficiency, the diagnosis of secondary Raynaud's phenomenon is easily made in most cases of this kind.

Severe vasospastic disturbances and Raynaud's phenomenon, leading in some instances to gangrene, may be produced by ergot intoxication either from ingestion of ergot bread or from administration of ergot preparations for medicinal purposes. Fortunately, these are relatively rare occurrences.

*Treatment.* In general, treatment is the same as for the primary form of the disease. Where possible, specific measures should be directed toward the primary factors. Satisfactory subsidence of symptoms usually follows elimination of these primary or underlying conditions such as the occlusive arterial disease, the neurogenic lesions or the traumatic or in-

toxicating factors. Adequate relief of symptoms, for example, frequently follows discontinuance of the use of vibrating tools in "pneumatic hammer disease." In some instances where symptoms persist despite conservative measures and elimination insofar as possible of the primary factors, sympathectomy may be indicated.

### ACROCYANOSIS[12-14]

Acrocyanosis is a peripheral vascular disturbance of unknown etiology characterized by painless, persistent coldness and cyanosis of the distal parts of the extremities. It is most frequently encountered in relatively young women. Although many patients with this condition show some evidence of endocrine dysfunction, its actual relationship to the vascular alterations remains obscure. Whereas some observers have attributed the color changes to dysfunction of the sympathetic nervous system, Lewis and Landis[14] concluded that the disturbance is local.

*Pathologic Physiology.* Neither the pathology of acrocyanosis nor the mechanism which produces the vascular changes is clearly understood. Lewis and Landis have demonstrated, by elevation of the cyanotic extremity, that no obstruction to venous drainage exists. Moreover, there are no demonstrable abnormalities in the large arteries of the extremity. Most observers believe that the primary disturbance lies in the smaller vessels. Lewis and Landis consider the defect to be local, producing increased arteriolar tone and an abnormal vasospastic response to ordinary environmental temperature, followed by secondary dilatation of the capillaries and venules. Other observers believe the changes are attributable to a hyperactive sympathetic nervous system. This concept is supported by Day and Klingman,[12] who observed that the hands of an acrocyanotic patient during sleep not only became warm and red, but also responded to heat and cold in the same way as the rest of the body.

*Symptoms and Signs.* The characteristic clinical manifestations of acrocyanosis are persistent coldness and bluish discoloration of the fingers and hands and, to a lesser extent usually, of the toes and feet. These manifestations are more prominent during cool than warm weather. Sweating of the palms and soles is sometimes pronounced, especially during periods of mental stress. Blanching does not occur but local pressure produces a white spot. The digits swell, particularly in cold weather, but ulceration, gangrene and other trophic changes do not occur. The normally palpable arteries usually show no evidence of occlusive disease.

*Diagnosis.* Little difficulty should be encountered in making the diagnosis, since the findings are usually characteristic. Although acrocyanosis is sometimes confused with Raynaud's disease, it may usually be readily distinguished from this condition by the persistence of the bluish discoloration in acrocyanosis as contrasted with its intermittent occurrence in Raynaud's phenomenon. In addition, pallor is not a feature of acrocyanosis. Absence of pain and increased heat in the affected regions also differentiate it from erythromelalgia.

*Treatment.* Conservative measures, particularly protection from cold, as in Raynaud's phenomenon, are usually adequate, since the condition is usually benign. In more severe cases sympathectomy may be indicated.

### ERYTHROMELALGIA[15-19]

The first careful study and clear description of this disease was made in 1878 by S. Weir Mitchell,[16] who suggested the term "erythromelalgia" because of the characteristic red, painful extremities. In 1938, Smith and Allen[18] suggested the more descriptive term "erythermalgia," which signifies, in addition to redness and pain, increased temperature of the part, another characteristic feature of the syndrome. Two forms of the condition are recognized: (1) primary or idiopathic erythermalgia, occurring in otherwise normal individuals, and (2) secondary erythermalgia, which is encountered in association with a number of conditions, including particularly hyperten-

sion, polycythemia vera, diabetes, gout and rheumatoid arthritis, as well as poisoning by heavy metals such as mercury, thallium and arsenic. The disease shows no predilection for sex but is commoner in the middle-aged and elderly.

*Pathologic Physiology.* Little is known about the pathology of this disease, owing to the paucity of available pathologic material for study. One of the most characteristic features of the disturbance is the response to increased cutaneous temperature. Although there is some variation among different patients in the range of temperature at which symptoms develop, the response is reasonably constant and usually takes place between 32° and 36° C. (89.6° to 96.8° F.). Above this temperature level, designated as the "critical point" by Lewis,[15] symptoms persist; below it, they disappear. Vasodilatation is believed to be the cause of the increased temperature. Further evidence of vasodilatation is provided by the presence of throbbing sensations, increased pulse volume and increased oxygen content of venous blood in the part. Variations in venous pressure also affect the symptoms since they are accentuated by dependency and diminished by elevation of the part. Even when the temperature is somewhat below the critical point, distress may be induced by increasing the venous pressure by means of a sphygmomanometer cuff applied to a proximal part of the extremity and inflated to about the diastolic blood pressure level. It would appear that the skin of erythromelalgic patients is sensitive to degrees of warmth that are well tolerated by normal persons, an observation which led Lewis to state that such patients have a "sensitive state of the skin"

*Symptoms and Signs.* Burning pain in the hands and feet, usually in the palms and soles, is the chief and most prominent complaint of these patients. It is aggravated by warmth of the extremity and therefore worse during the summer. Patients usually recognize this relationship and often volunteer the information that relief may be obtained by exposing the parts to a cool environment, sleeping with the feet exposed to cold air or immersing the feet in cold water. Examination of the painful extremity reveals it to be red or cyanotic, and the skin feels warm or hot. There may also be some swelling or puffiness of the affected part. In the primary form there is usually no evidence of occlusive arterial disease.

*Diagnosis.* The diagnosis can usually be made on the basis of the characteristic clinical manifestations and their specific relationship to the level of temperature or the presence of a "critical point," at which the burning distress develops. It is important to distinguish the burning paresthesia accompanying occlusive arterial disease from similar manifestations in erythromelalgia. This distinction can readily be made if it is recalled that in the former condition there is coldness or, at the most, normal warmth of the part, whereas in erythromelalgia there is increased warmth of the part. Efforts should also be made to determine whether the condition is primary or secondary, and appropriate studies should be undertaken to determine the presence or absence of polycythemia vera, diabetes and other underlying diseases, as previously indicated.

*Treatment.* Treatment of erythromelalgia is generally unsatisfactory. If the condition is secondary, treatment should be directed toward the underlying process. Avoidance of conditions that produce vasodilatation may provide some symptomatic relief. Accordingly, patients should be advised to wear lightweight socks or stockings and perforated shoes or sandals and to avoid exposure of the feet to a warm environment. Some patients seem to obtain a surprising degree of relief from acetylsalicylic acid (10 grains). Peripheral nerve crushing may be indicated in extremely severe cases if all other measures have been unsuccessful.

### ARTERIOSCLEROSIS[20-35]

Arteriosclerosis, the commonest disease of the arteries, is a degenerative process of the arterial wall. The pathologic entity resulting from this disease depends upon the form of involvement which the

process may assume. In some cases the disease is located primarily in the medial arterial layer and is characterized by cystic degeneration, calcium deposition, fragmentation of the elastic fibers and arterial dilatation. These pathologic changes lead to progressive arterial dilatation resulting in arterial aneurysm. This particular form of the disease will be discussed in more detail later. In other cases pertinent to the present discussion, the involvement is primarily intimal and is characterized by atheroma formation consisting of hypertrophied intima and subintimal deposits of lipid material. Progressive enlargement of the atheroma results in luminal constriction, thrombosis, arterial occlusion and arterial insufficiency. This condition is known as arteriosclerosis obliterans, arteriosclerotic peripheral vascular disease or atherosclerotic occlusive vascular disease. Virchow accurately described this disease in the middle of the last century, and although it has since been intensively studied, its etiology is still not clearly understood. Recent studies indicate that derangement of lipid metabolism is probably the most important single etiologic factor. The disease is ten times more frequent in men than in women and develops more often and earlier in diabetic than in nondiabetic patients. It is primarily a disease of middle and old age, with the highest incidence after the age of 40 years.

*Pathology.* Atheroma formation, destructive degeneration of the media and thrombosis constitute the essential pathologic changes of arteriosclerosis. Because of the progressive nature of the disease, these lesions may be in various stages of development in different parts of the artery. Grossly, the arteries appear enlarged, tortuous and somewhat irregular, and on section irregular atheromatous plaques may be observed projecting into the lumen for varying distances. These white to yellow atheromatous patches tend to develop on one side of the artery rather than concentrically. Calcareous deposits may be found at the base of the plaques or in the media, with thrombi in various stages of organization producing partial or complete occlusion of the lumen. Microscopic examination discloses the atheromas to be thickening of the intima, which is composed of connective tissue and fat-laden phagocytes. The more advanced lesions may have a hyalin-like appearance and contain fat, lipoid material, lipophages, cholesterol and fibrous tissue. Deposits of calcium at the base of the atheroma may also be present. In other areas erosion of the atheromatous plaque may have produced a ragged atheromatous ulcer, which may be covered by layers of thrombus formation. The internal elastic lamina is frequently fragmented and frayed. In the early stages the medial coat may be only slightly affected, but later the muscles of this coat undergo a destructive degenerative process characterized by fragmentation, thinning, fibrous tissue replacement and calcium deposition. The adventitia usually shows relatively little change, consisting mainly of irregular fibrosis and collections of lymphocytes.

As indicated above, the disease begins with intimal proliferation and deposition of lipoid material in the subintimal layer of the arterial wall. Continuing deposition of this substance and local changes in the deposit itself, such as for-



*Figure 243.* Femoral artery occluded by atheroma and thrombus. Calcification is present in the media.

eign body reaction and calcification, result in formation of an atheroma. Although this lesion may be extensive, it is more frequently localized, being only 1 or 2 cm. in length and involving part or all the circumference of the vessel near its origin or bifurcation. As the atheroma enlarges, more and more of the lumen is consumed. Eventually, a critical point of narrowing is reached until flow through the constriction is retarded sufficiently to create an environment for intravascular clotting, and with the resulting thrombosis complete occlusion of the lumen takes place. Under these circumstances, clotting extends proximally until a collateral branch is reached that permits rapid and more complete egress of blood into the collateral bed, and distally until a collateral branch is reached through which sufficient blood is flowing from the collateral bed into the central artery at a rate of flow that does not allow clotting to take place. Consequently, the occlusion seen at operation or on roentgenographic examination is segmental and consists to a large extent of a thrombus in varying stages of organization. The arteriosclerotic element itself may represent only a small part of the occlusion, and the artery both above and below this region may be entirely normal.

Characteristically, this disease involves arteries such as the coronary, innominate, common and internal carotid, subclavian, vertebral, superior mesenteric, renal, iliac, femoral and popliteal arteries and the terminal aorta at its bifurcation. The obstruction of blood flow through these large arteries and the consequent ischemia of the tissues supplied by these vessels constitute the essential physiologic disturbance. Accordingly, the extent of this disturbance is dependent upon several factors, the most important of which are the level and extent of obstruction and the rapidity of its development. Fortunately, the occlusive process usually takes place gradually, permitting time for the development of collateral channels. In general, the higher and more limited the occlusive process, the more effective is the collateral blood flow. In no instance, however, does the collateral blood flow equal in effectiveness the blood flow through the main vessels, because even if the cross-sectional area of the vascular bed is augmented, the peripheral resistance is increased, causing a significant diminution in effective blood flow. The extent of the occlusive process in the artery is significantly related to the effectiveness of collateral blood flow. When the occlusive process involves a relatively short segment of the vessel, more and larger anastomotic channels are available to convey blood around the point of obstruction. Probably the most important factor in determining adequacy of collateral blood flow is the rapidity with which the occlusive process takes place. Gradual obstruction of the main artery permits time for the normally little used collateral anastomotic channels to develop functionally and to undergo dilatation. Under these circumstances adequate blood flow may be maintained to nourish the part and eventually may even be gradually increased. On the other hand, if the occlusive process takes place rapidly, the anastomotic collateral channels may simply be incapable of meeting this sudden demand to convey an adequate amount of blood to nourish the tissues and prevent their death. This difficulty is further aggravated by the tendency under these circumstances for extensive thrombosis to occur in the main channel distal to the point of sudden occlusion, thus diminishing the number of available collateral vessels and increasing the distance of blood flow through the smaller collateral vessels.

Other factors affecting the degree of ischemia in this form of occlusive arterial disease include those which produce vasospasm, such as tobacco and exposure to cold. It is important to realize that normal tone and vasoconstrictor function in the smaller arteries and arterioles may be well maintained in this form of occlusive disease, even though the larger arteries may be extensively involved in the arteriosclerotic process and consequently devoid of such function. Indeed, the capacity for vasoconstriction and

vasodilatation in arteriosclerosis obliterans may be equal to, and may even exceed, that in thromboangiitis obliterans. For this reason, measures designed to prevent vasoconstriction and to produce vasodilatation may have significant therapeutic value in some cases.

*Symptoms and Signs.* The symptoms and signs of this disease are due primarily to ischemia of the tissues. The clinical manifestations of ischemia vary according to the location of obstruction, and in view of the variation with which this occurs, the disease may be divided into a variety of clinical entities. Angina pectoris and myocardial infarction result from occlusion of the coronary arteries. Renal artery obstruction causes hypertension, and occlusion of the superior mesenteric artery is manifested by certain gastrointestinal disturbances such as diarrhea, malabsorption, postprandial cramping abdominal pain (abdominal claudication), and eventually mesenteric infarction. Arterial insufficiency of the lower extremities is produced by occlusive lesions of the terminal aorta, and iliac, femoral and popliteal arteries. Occlusive lesions of the great vessels (innominate, left common carotid and left subclavian arteries) arising from the aortic arch are associated with arterial insufficiency of the cerebrum and upper extremities. Occlusion of the internal carotid and vertebral arteries is manifested by cerebral ischemia. In view of space limitations only the latter categories of arterial insufficiency are discussed in detail. A more comprehensive consideration of the other less frequently encountered conditions may be obtained from the list of references at the end of this chapter.

*Arterial Insufficiency of the Lower Extremities.* As previously indicated, the lesion causing this disturbance may be located in the distal aorta, or iliac, femoral or popliteal arteries. The symptoms of this condition may develop abruptly as a result of thrombosis or gradually as a result of progressive narrowing and obliteration of the lumen. Accordingly, the symptoms may be mild or severe, depending upon the extent and progress of the occlusive process.

In the gradually progressive form of the disease, one of the earliest and commonest symptoms is intermittent claudication. The patient complains of cramping pain or sense of extreme fatigue in the foot, calf or thigh on exercise, with rather prompt relief on resting. Rapid walking or climbing accentuates the claudication. It usually begins unilaterally, and although it may later become bilateral, it tends to be worse on one side.

In the more advanced stages of the disease, the patient may have "rest pain," a constant aching, burning discomfort, often experienced at night in the distal part of the extremity, primarily the feet and toes. It is generally indicative of severe ischemia and a poor prognosis unless properly treated. Patients with this type of pain often assume a rather characteristic sitting position with the affected leg flexed and the foot cradled in the hand for protection and warmth. Another type of pain is that of ischemic neuritis, which tends to follow the peripheral distribution of the nerves and to be of a severe burning or stabbing character.

Other complaints include tingling or prickling paresthesia, numbness or deadness, or a sensation of coldness, usually in the toes or feet. Persistent anesthesia, particularly the stocking type, is indicative of severe ischemia. Muscular weakness is also evidence of severe arterial insufficiency.

The physical findings vary somewhat, depending upon the degree and duration of the occlusive process. In the early stages, inspection may reveal few abnormalities. Later, the skin of the foot, and particularly the toes, may be red with patches of discoloration. In more advanced cases the skin may appear pale, shiny and atrophic, with an almost cadaveric hue. The subcutaneous fat is diminished, and the muscles are atrophic, producing a "skeletonized" appearance. Ulceration and gangrene, often precipitated by trauma, may develop, usually

eign body reaction and calcification, result in formation of an atheroma. Although this lesion may be extensive, it is more frequently localized, being only 1 or 2 cm. in length and involving part or all the circumference of the vessel near its origin or bifurcation. As the atheroma enlarges, more and more of the lumen is consumed. Eventually, a critical point of narrowing is reached until flow through the constriction is retarded sufficiently to create an environment for intravascular clotting, and with the resulting thrombosis complete occlusion of the lumen takes place. Under these circumstances, clotting extends proximally until a collateral branch is reached that permits rapid and more complete egress of blood into the collateral bed, and distally until a collateral branch is reached through which sufficient blood is flowing from the collateral bed into the central artery at a rate of flow that does not allow clotting to take place. Consequently, the occlusion seen at operation or on roentgenographic examination is segmental and consists to a large extent of a thrombus in varying stages of organization. The arteriosclerotic element itself may represent only a small part of the occlusion, and the artery both above and below this region may be entirely normal.

Characteristically, this disease involves arteries such as the coronary, innominate, common and internal carotid, subclavian, vertebral, superior mesenteric, renal, iliac, femoral and popliteal arteries and the terminal aorta at its bifurcation. The obstruction of blood flow through these large arteries and the consequent ischemia of the tissues supplied by these vessels constitute the essential physiologic disturbance. Accordingly, the extent of this disturbance is dependent upon several factors, the most important of which are the level and extent of obstruction and the rapidity of its development. Fortunately, the occlusive process usually takes place gradually, permitting time for the development of collateral channels. In general, the higher and more limited the occlusive process, the more effective is the collateral blood flow. In no instance, however, does the collateral blood flow equal in effectiveness the blood flow through the main vessels, because even if the cross-sectional area of the vascular bed is augmented, the peripheral resistance is increased, causing a significant diminution in effective blood flow. The extent of the occlusive process in the artery is significantly related to the effectiveness of collateral blood flow. When the occlusive process involves a relatively short segment of the vessel, more and larger anastomotic channels are available to convey blood around the point of obstruction. Probably the most important factor in determining adequacy of collateral blood flow is the rapidity with which the occlusive process takes place. Gradual obstruction of the main artery permits time for the normally little used collateral anastomotic channels to develop functionally and to undergo dilatation. Under these circumstances adequate blood flow may be maintained to nourish the part and eventually may even be gradually increased. On the other hand, if the occlusive process takes place rapidly, the anastomotic collateral channels may simply be incapable of meeting this sudden demand to convey an adequate amount of blood to nourish the tissues and prevent their death. This difficulty is further aggravated by the tendency under these circumstances for extensive thrombosis to occur in the main channel distal to the point of sudden occlusion, thus diminishing the number of available collateral vessels and increasing the distance of blood flow through the smaller collateral vessels.

Other factors affecting the degree of ischemia in this form of occlusive arterial disease include those which produce vasospasm, such as tobacco and exposure to cold. It is important to realize that normal tone and vasoconstrictor function in the smaller arteries and arterioles may be well maintained in this form of occlusive disease, even though the larger arteries may be extensively involved in the arteriosclerotic process and consequently devoid of such function. Indeed, the capacity for vasoconstriction and

determined by this finding. In patients with complete occlusion, pulses are not palpable beyond the point of obstruction except in those few patients in whom large collaterals have developed around the occlusion. With these relatively infrequent exceptions, femoral occlusions have palpable pulses in the groin but absent popliteal and pedal pulses. Unilateral iliac occlusions are associated with absent pulses throughout the involved extremity and normal pulses throughout the opposite limb. Pulses are absent throughout both lower extremities in patients with aortic and bilateral iliac occlusions. Aortic and femoral pulses, when present, offer little or no difficulty to palpation; however, popliteal and pedal pulses, even when normal, are sometimes difficult to elicit. In view of the importance of the pulse findings in the popliteal and pedal regions, this part of the examination is considered in detail.

POPLITEAL PULSE. The popliteal artery is most accessible to palpation in the popliteal fossa directly behind the patella. The artery at this level is located



*Figure 246.* Gangrene of the fourth and fifth toes due to arteriosclerosis obliterans.



*Figure 247.* A localized area of ulceration and gangrene involving the left great toe in a patient with arteriosclerosis obliterans and diabetes mellitus.

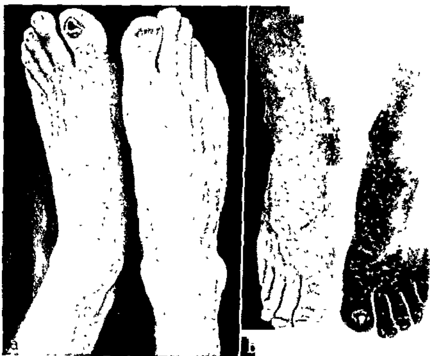


*Figure 244* Pronounced postural color changes in patient with arteriosclerosis obliterans *a*, Pallor on elevation; *b*, rubor on dependency.

on the toes first but occasionally on the dorsum of the foot, about the ankles or even higher on the leg.

Postural color changes, consisting of abnormal pallor on elevation well above heart level and rubor and cyanosis on dependency, are characteristic of occlusive arterial disease and constitute a reliable index of the degree of arterial insufficiency. The time required for venous filling may similarly provide information of this nature. Normally, the superficial veins of the feet empty readily and assume a collapsed appearance upon elevation of the extremities but completely refill within 10 to 12 seconds after the feet are returned to a slightly dependent position. In patients with occlusive arterial disease, the time required for venous filling is significantly prolonged.

Another fairly characteristic finding is diminution of cutaneous temperature in the affected part. It can usually be detected by simple palpation and particularly by comparison with the opposite extremity.

The presence of edema in the foot and leg is usually indicative of advanced disease and generally occurs in association with severe pain and gangrenous lesions.



*Figure 245.* Arteriosclerosis obliterans of the left lower extremity with gangrene of the fourth and fifth toes and dorsum of the foot The absence of hair and shiny atrophic appearance of the skin are indicative of severe ischemia

It usually develops after the patient has been sitting for long periods with the foot in a dependent position in order to relieve pain.

The most significant finding on physical examination in these cases is the change in the peripheral pulses, and the location of the occlusion can usually be

determined by this finding. In patients with complete occlusion, pulses are not palpable beyond the point of obstruction except in those few patients in whom large collaterals have developed around the occlusion. With these relatively infrequent exceptions, femoral occlusions have palpable pulses in the groin but absent popliteal and pedal pulses. Unilateral iliac occlusions are associated with absent pulses throughout the involved extremity and normal pulses throughout the opposite limb. Pulses are absent throughout both lower extremities in patients with aortic and bilateral iliac occlusions. Aortic and femoral pulses, when present, offer little or no difficulty to palpation; however, popliteal and pedal pulses, even when normal, are sometimes difficult to elicit. In view of the importance of the pulse findings in the popliteal and pedal regions, this part of the examination is considered in detail.

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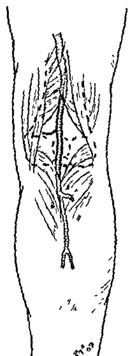


*Figure 248.* Location of popliteal artery in popliteal fossa midway between medial and lateral hamstring muscles

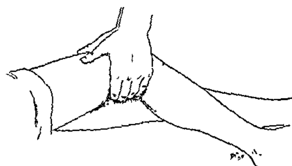


*Figure 249.* Method of palpation of popliteal artery pulse by placing finger tips of both hands in space between hamstring tendons with patient's knee slightly flexed.

midway between the medial and lateral hamstring muscle tendons and is covered only by skin, fascia and loose fatty areolar tissue (Fig. 248). Ordinarily, its pulsations are well transmitted from this region. Muscle contraction and extension of the lower leg places the tough popliteal fascia under tension so that the pulse is difficult to feel. Accordingly, when this artery is examined for pulsations, the hamstring muscles should be relaxed and the knee slightly flexed. This can be accomplished by either of two techniques. First, with the examiner facing the patient, who is supine, the knee is grasped between both hands and

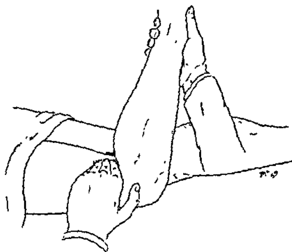


*Figure 250.* Method of palpation of popliteal artery pulse by placing examiner's fingers over popliteal fossa with patient in prone position and knee flexed.

lifted slightly above the table to about 15 degree flexion. During this maneuver the finger tips of both hands are placed in the space between the hamstring tendons and, if the knee is flexed and relaxed, pulsations can be felt in the popliteal artery (Fig. 249). The second maneuver that facilitates detection of this pulsation consists of placing the patient in the prone position and flexing the knee about 90 degrees (Fig. 250). The popliteal fossa is thus relaxed and pulsations are easily detected by palpation over the course of the artery.

DORSALIS PEDIS PULSE. The dorsalis

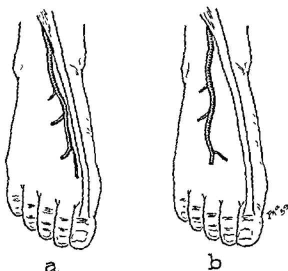



*Figure 251.* Location of dorsalis pedis artery (*a*) usually just lateral to extensor hallucis longus tendon or (*b*) in a somewhat more lateral position.



*Figure 252.* Method of palpation of dorsalis pedis artery.

pedis artery is the pedal extension of the anterior tibial artery and in 90 per cent of patients it is located just lateral to the extensor tendon of the big toe (extensor hallucis longus) (Fig. 251*a*). In the remainder of patients it may be located anywhere between this point and a line drawn down the foot from the fifth toe to the lateral malleolus (Fig. 251*b*). In order to palpate for this pulse, it is recommended that the examiner, facing the patient, grasp the foot between thumb and fingers of the contralateral hand so that the thumb extends across the sole and the fingers spread out across the dorsum of the foot (Fig. 252). The pulse is easily located in this position by shifting the four finger tips about the dorsum of the foot after gentle dorsiflexion of the foot to relieve tendon and arterial tension.

POSTERIOR TIBIAL ARTERY. There are at least two consistent landmarks for the posterior tibial artery at the ankle. Immediately posterior to the lateral malleolus, one is halfway between this structure and the medial edge of the Achilles tendon (Fig. 253). The other is immediately under the sustentaculum tali between the malleolus and the sole of the foot (Fig. 253). The easiest, most satisfactory method of examination for this artery is to face the patient and grasp the ankle with the contralateral hand so that the thumb extends over the lateral aspect of the ankle and the finger tips of the other four fingers fall into the region of the posterior tibial artery (Fig. 254). Slight dorsiflexion and external rotation with the other hand, combined with gentle palpation, greatly facilitate the location of this pulse.

DIAGNOSIS. The diagnosis of arteriosclerotic occlusive arterial disease of the lower extremities may be made from the clinical manifestations, including particularly the presence of intermittent claudication, rest pain, coldness of the extremities, postural color changes, decrease in cutaneous temperature and, above all, absence or impairment of peripheral pulses. The occurrence of these

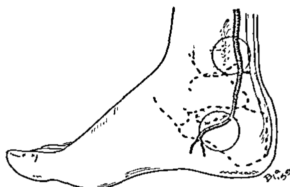


*Figure 253.* Anatomic location of posterior tibial artery either (upper circle) immediately posterior to lateral malleolus and between this structure and the medial edge of tendon of Achilles or (lower circle) immediately under sustentaculum tali.

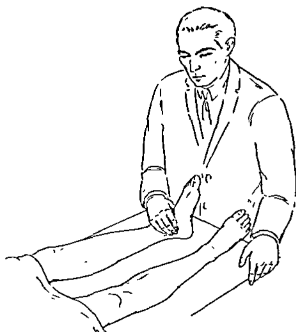


*Figure 254.* Method of palpation of posterior tibial artery.

manifestations in patients of any age should be attributed to arteriosclerosis until proved otherwise. Thromboangiitis obliterans may produce similar symptoms, but experience with the direct operative treatment of chronic arterial occlusion has clearly demonstrated that thromboangiitis is a rare condition. Other evidence of arteriosclerosis, such as pathologic changes in the retinal vessels, evidence of coronary artery disease or roentgenographic demonstration of irregular calcification in the peripheral arteries, constitutes additional confirmation of the diagnosis.

Although the diagnosis of arterial insufficiency as well as the site of occlusion may be made on the basis of the clinical findings in most cases, arteriography is essential to determine the precise location of the lesion and the condition of the vascular bed distal to the occlusion. The latter assumes great importance in the selection of therapy. The technique of arterial visualization varies with the segment of artery being studied. For example, occlusions of the aorta and iliac arteries are visualized by inserting a needle through the back into the aorta above the lesion, injecting 25 cc. of radiopaque substance (85 per cent Hypaque), and roentgenographic exposure of the abdomen and pelvis. A roentgenogram obtained in this manner outlining the abdominal aorta and its branches is called an aortogram (Figs. 255 and 256). The femoral and popliteal arteries are visualized in a similar manner by inserting a needle into the common femoral artery in the groin, injecting 25 cc. of contrast substance (30 per cent Hypaque), and roentgenographic exposure of the thigh and lower leg. A roentgenogram outlining the femoral artery and its branches is called a femoral arteriogram (Fig. 257). Occlusive lesions appear as defects or gaps in the brilliantly outlined vessel, the distal segment being filled by flow through the collateral channels (Fig. 256).



*Figure 255.* Aortogram in patient with manifestations of arterial insufficiency of lower extremities, showing partial occlusion of right iliac artery and of abdominal aorta immediately above bifurcation and complete occlusion of left iliac artery.

TREATMENT. Treatment of arteriosclerotic arterial insufficiency of the lower extremities is directed toward restoration of normal circulation in the main arterial channel. The frequent localization of the occlusion to vessels of relatively large caliber with a normal segment both above and below the occlusion has permitted application of certain operative approaches directed toward the lesion itself. Well localized discrete occlusions may be removed by the technique known as thromboendarterectomy. This procedure consists of opening the artery either transversely or longitudinally, entering the cleavage plane between the diseased intima and normal outer layers of the arterial wall and removing the obstructing mass. More extensive lesions are better treated by the end-to-side bypass graft technique because the operation is simpler to perform and is less likely to be associated with damage to the patient's own collateral channels This procedure consists of exposing the normal uninvolved arterial segment both above and below the occlusion, usually through two small separate incisions. One end of a graft is sutured to the side

of the artery above the lesion and the other end of the graft is sutured to the normal patent distal segment. The graft is brought from one incision to the other through a tunnel made by blunt dissection employing a long clamp or an instrument specially designed for this purpose. At the completion of operation normal circulation is immediately diverted around the occluded segment into the patent distal arterial bed. Some patients have a combination of medial and intimal disease resulting in both aneurysm formation and luminal obstruction. The lesion associated with a weakened arterial wall is completely excised and replaced with a suitable arterial substitute. In still other patients, various combinations of these three basic procedures may be employed depending upon the location, nature and extent of the lesion.

The application of these direct pro-





*Figure 256* Aortogram in patient with manifestations of arterial insufficiency of lower extremities showing segmental occlusion of right superficial femoral artery with patent popliteal artery and more extensive occlusive disease involving left femoral and popliteal artery. The former is amenable to surgical treatment designed to restore normal circulation by employing bypass graft method The latter is preferably treated by means of lumbar sympathectomy.



*Figure 257.* Femoral arteriogram showing segmental occlusion of right superficial femoral artery with patent popliteal artery.

cedures designed to restore normal circulation immediately, as previously indicated, depends upon the localized or segmental nature of the occlusion. This pathologic feature of the disease is related to some extent to the location of the lesion. For example, occlusions of the distal aorta and iliac arteries, for practical purposes, are always segmental and susceptible to direct operation (Fig. 255). Lesions of the femoral and popliteal arteries are usually but not always segmental, varying with the duration and severity of the clinical manifestations of the disease. The obstruction is localized and susceptible to direct operation in 90 per cent of patients with mild and approximately 50 per cent of patients with severe manifestations of arterial insufficiency (Fig. 257). In the remaining patients with occlusions at this level the lesion is diffuse, extending distally to involve the smaller vessels of the lower leg (Fig. 256). In the absence of a sizable patent distal segment, direct operation is technically impossible (Fig. 256).

The objectives and general principles of treatment in the latter patients consist essentially in the elimination or avoidance of those factors which enhance progression of the disease and the institution of certain measures designed to improve the circulation in the part. Among these, consideration may first be given to a protective regimen directed towards reducing the metabolic requirements of the part, avoidance of excessive stress or strain, elimination of vasoconstrictor factors, such as use of tobacco and exposure to cold, and institution of physiologic rest of the part. Patients should be carefully instructed regarding foot hygiene, including particularly cleansing of the feet with a bland soap and warm water followed by thorough drying, careful trimming of the nails to avoid any injury to the tissues, and wearing of comfortable, well-fitting shoes and warm socks. Absolute control of fungous infection is essential. Chilling of the body, as well as of the feet, should be avoided, and special precaution should be taken against any form of trauma to the feet. Physiologic rest of the part and a warm, comfortable environment may be beneficial in patients in whom more active measures for increasing blood flow cannot be instituted. However, heat should never be applied directly to the involved extremity, since elevation of the temperature by this means increases the metabolic requirement of the part and, consequently, imposes additional demands for blood flow which cannot be met. During bed rest the position of the involved part in relation to heart level is important. The feet should be slightly below heart level, and for this reason it is advisable to elevate the head of the bed approximately one foot. Although physiologic rest to the part is desirable, in the presence of impending or actual gangrene or ulceration, prolonged complete inactivity should be avoided when possible, and efforts should be made to encourage some physical exercise in order to maintain and improve the tone of the muscles and to stimulate the development of collateral circulation.

Improvement in circulation is the primary objective of therapy in this form of the disease with diffuse peripheral arterial occlusion. To this end, various measures have been proposed, including postural exercises, reflex heat, tissue extracts, foreign protein injections and certain vasodilator drugs, such as papaverine, tetraethyl ammonium chloride and Priscoline. In general, these measures provide only transitory and varying degrees of generalized vasodilatation, and none has proved consistently effective. Postural exercises and reflex heat are perhaps the simplest to employ and are about as effective as any.

Sympathectomy, which is the most effective means of improving local circulation in the part, is the method of choice unless definite contraindication to operation exists. The rationale and value of sympathectomy in arteriosclerotic peripheral vascular disease have been well established. The procedure consists essentially in release of constrictor tonus, which may or may not be excessive, depending upon the type and stage of the disease. By this means it permits main-

tenance of the maximal degree of vasodilatation in the denervated area, thus producing an increase in the volume of the local vascular bed and consequent improvement in the local circulation. In this respect the objective of the procedure conforms to that concept of hemodynamics to which the term hemometakinesia has been applied and thus provides a further rational basis for sympathectomy. This concept is derived from certain observations concerning the physiologic features of the circulation which establish the presence of spontaneous and even rhythmic fluctuations in the volume of the vascular bed primarily attributable to changes in the volume of blood within the part. These fluctuations in blood volume in different parts of the body can occur without any alteration in total blood volume or cardiac output by adjustment of the vascular bed which permits, spontaneously, an increase in the volume of blood (through vasodilatation) of one part of the body with a corresponding decrease (through vasoconstriction) elsewhere. This compensatory process, permitting the "borrowing and lending" of blood by various tissues to meet variations in requirements, is indicative of a well regulated mechanism designed to permit the body to utilize its limited total blood volume in the most efficient manner. The sympathetic nervous system plays an important role in this mechanism of control and regulation of the peripheral vascular bed. Interruption of the sympathetic pathway to the part removes the vasoconstrictor factor in this mechanism, resulting in maximal vasodilatation in the vascular bed of the affected part. Other means of producing such vasodilatation, by use of vasodilator agents administered systemically, have long been attempted with little success. These agents, for the most part, produce transitory and varying degrees of generalized vasodilatation. In most peripheral vascular disturbances, however, impairment in circulation is usually localized to one or two peripheral parts. Accordingly, therapeutic efforts should rationally be directed not toward production of vasodilatation of the entire vascular bed but rather toward production of local vasodilatation limited to the part in need of more blood.

The most suitable patients for sympathectomy are those who have the more slowly progressive forms of the disease with moderate degrees of involvement. Gratifying results may also be obtained, however, even in patients with impending or actual gangrene, in whom sufficient improvement of the circulation may be obtained to permit better control of infection and rapid arrest of the ischemic process with minimal loss of tissue. Definite contraindications to operation include severe cerebral, cardiac, renal or pulmonary involvement, a far advanced and rapidly progressive process, and pronounced atrophic changes in the extremity.

In the presence of local lesions, such as infection, ulceration and gangrene, general conservative management is desired. This includes bed rest, chemotherapy to control infection and use of warm compresses of boric acid or saline solution to promote drainage and aid in removal of necrotic tissue. Great care and gentleness must be exercised in handling these local lesions, because the tissues at the base of the gangrenous ulcers are extremely vulnerable to injury. Ointments and antiseptic solutions should be avoided. Necrotic tissue and loose slough may be removed by gentle excision without injury to viable tissue. Localized gangrene of the toes should be allowed to demarcate completely before removal is attempted.

*Arterial Insufficiency of the Cerebrum and Upper Extremities.* The lesions causing these disturbances tend to assume two patterns of involvement, namely, a proximal and distal form. In the proximal form the occlusion is located in one, two or three of the great vessels (innominate, left common carotid and left subclavian arteries) near their origin from the aortic arch. The clinical manifestations of the disease at this level are characterized by arterial insufficiency of both the cerebrum and upper extremities. Because of the proximal location of

the lesions, considerable collateral blood flow develops concomitantly with narrowing and occlusion of the central channels; consequently, symptoms are frequently mild, consisting either of intermittent claudication of the upper extremities or of certain cerebral disturbances such as transient episodes of paralysis, sensory disturbances and visual defects. In other cases both types of symptoms may be present. The more advanced cases may be associated with persistent neurologic defects and actual gangrene of the fingers and hand.

The physical findings in patients with proximal forms of occlusion include neurologic defects and manifestations of arterial insufficiency of the upper extremities. The most frequent abnormalities in these cases are those associated with the arteries of the arms and neck. Pulsations transmitted by these vessels are frequently diminished or absent. Blood pressure in the upper extremities is frequently diminished or absent, or varies from one extremity to the other. Systolic murmurs indicating partial obstruction are frequently heard in the neck and supraclavicular regions. Unilateral carotid compression may cause syncope or the onset of peripheral neurologic disturbances indicating occlusion of the opposite carotid artery.

The lesions in the distal form of the disease are located in the internal carotid and vertebral arteries or branches of these vessels. Although the obstruction may occur in a small inaccessible intracranial branch in many cases, the occlusion is segmental and located at the origin of these vessels in the neck in over 30 per cent of the cases. The latter type of obstruction is susceptible to operation. The clinical manifestations of these lesions depend upon the location and extent of the occlusive process. The internal carotid artery supplies blood to the anterior and middle lobes of the brain and the retina. Occlusion of this vessel causes mono-ocular visual disturbances, unilateral motor and sensory defects and aphasia. The vertebral arteries unite at the base of the brain to form the basilar artery, the branches of which supply blood to the brain stem, cerebellum and visual cortex. Vertebral artery occlusion, usually bilateral, is associated with bilateral visual disturbances, bilateral motor and sensory changes and vestibular dysfunction. Early in the course of vertebral or internal carotid artery occlusive disease, symptoms are mild and transitory; however, as the occlusive process becomes more complete, severe arterial insufficiency develops, manifested by persistent paralysis, aphasia and mental obtundity.

Physical examination in patients with the distal form of the disease may be entirely normal in the early stages of the disease. Neurologic defects in the form of paralysis and aphasia may be present in the more advanced cases. The pulses of the face, throat and neck are normal even in the advanced forms of the disease and are of little help in diagnosis. Systolic murmurs may be heard under the angle of the jaw in most cases with incomplete occlusion of the internal carotid artery in the neck. Unilateral carotid compression may produce neurologic disturbances indicating obstruction and arterial insufficiency of the opposite carotid artery.

DIAGNOSIS. The diagnosis of occlusion in the proximal forms of the disease can be made from the clinical manifestations of arterial insufficiency of both the cerebrum and upper extremities, including particularly the presence of intermittent claudication in the upper extremities, the presence of systolic murmurs in the base of the neck and supraclavicular region, and above all, absence or impairment of pulses in the neck and arms. Diminution or absence of blood pressure and variation of blood pressure from one arm to the other indicates subclavian artery obstruction. Precise localization of the obstruction, hence confirmation of the diagnosis, is obtained by thoracic aortography. The arm-to-tongue circulation time is determined, after which the appropriate contrast substance (50 cc. of 85 per cent Hypaque) is injected into an antecubital vein. Roentgenographic exposure of the chest and neck is then performed after delaying an interval

equal to the arm-to-tongue circulation time. A roentgenogram performed in this manner outlines the thoracic aorta and great vessels arising from the aortic arch. Occlusions of these vessels are demonstrated as defects or gaps in the columns of contrast substance outlining the arteries (Fig. 258).

The diagnosis of cervical arterial obstruction in the distal forms of the disease is difficult to establish on clinical grounds alone. The history of transient attacks of cerebral arterial insufficiency with visual disturbances, the presence of systolic murmurs in the neck and the precipitation of cerebral disturbances by carotid compression are highly suggestive of distal occlusion; however, accurate diagnosis and precise localization of the lesion are obtained by arteriography which varies according to the vessel being studied. Carotid arteriography is performed by radiographic exposure of the neck in the lateral position as contrast material is being injected into the common carotid artery in the neck. The carotid arteries are well outlined by this technique, and the occlusive lesion is demonstrated as a defect in the contrast material usually at the origin of the internal carotid artery (Fig. 259). Vertebral arteriography is performed in a similar manner except that the contrast material is injected into the supraclavicular segment of the subclavian artery and roentgenographic exposure is made of the head, neck and upper chest in the anteroposterior position. The subclavian and vertebral arteries are well outlined and occlusive lesions of the vertebral arteries are demonstrated as defects in the vessel outline near the origin of the vertebral arteries.

TREATMENT. Treatment of arteriosclerotic arterial insufficiency of the cerebrum and upper extremities, as in occlusive arterial disease in general, consists of restoration of normal arterial blood

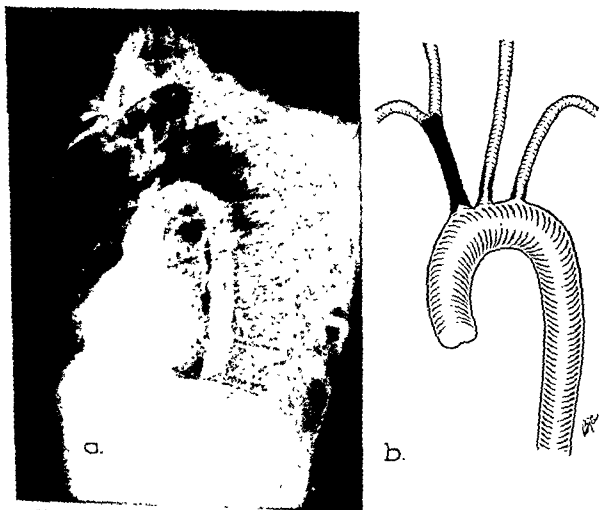



*Figure 258.* Aortogram showing occlusion of innominate, carotid and subclavian arteries.




*Figure 259.* Carotid arteriogram showing partial occlusion of internal carotid artery near its origin at carotid bifurcation.

flow to the part distal to the obstruction. In general, two procedures may be employed at this level for this purpose. Occlusions discretely localized to a short segment of artery less than 2 cm. in length may be removed by endarterectomy. The more extensive occlusions are treated by end-to-side bypass graft. The graft in patients with occlusion of the vessels arising from the aortic arch extends from the ascending aorta to the patent vessels distal to the occlusion. In patients with occlusion of the internal carotid artery, the graft extends from the normal proximal common carotid artery to the patent internal carotid artery distal to the occlusion.

#### THROMBOANGIITIS OBLITERANS[36-46]

Thromboangiitis obliterans is a disease involving primarily the medium-sized or small vessels of the extremities. It is characterized by a segmental, nonsuppurative inflammatory process associated with thrombosis in the artery, and often in the adjacent vein, and thus producing an organic occlusion of the vessel. It is often called Buerger's disease after the classic description of the condition by Leo Buerger, in 1908.[37] Although the disease may involve the vessels of the upper extremities, it occurs most commonly in those of the lower extremities. The visceral vessels are rarely affected. The etiology of the disease is not known although numerous factors have been considered, the most important of which are the effects of tobacco. Whereas its exact role is not understood, tobacco smoking appears to be closely related to the development of the disease, and there can be no doubt of its aggravating influence. Its occurrence in nonsmokers is extremely rare. Another striking feature is its predilection for the male sex; no satisfactory explanation for the relative

immunity of women has been provided. Although the disease has been encountered in all races, its incidence is much higher in the white than in the Negro race. It also occurs primarily in young or middle-aged adults, during the third to the fifth decade.

*Pathology.* The pathologic features of thromboangiitis obliterans are fairly characteristic and consist essentially in panarteritis, panphlebitis and thrombosis. Most commonly affected are the medium-sized or small vessels, such as the anterior and posterior tibial, radial and ulnar arteries. As the disease progresses, larger arteries, like the femoral and brachial, may be affected. Frequently the artery, vein and nerve are bound together in the inflammatory process. The thrombus becomes organized early in the development of the disease, with dense ingrowth of connective tissue. Following organization, varying degrees of recanalization may take place. Because of the segmental nature of the lesion, normal segments of vessels may be interposed between diseased segments. Histologically, the arteries and veins show proliferation of the endothelial cells of the intima with infiltration of lymphocytes. The lumen is occluded by organized thrombus, which contains many endothelial cells and fibroblasts. Contrasted with arteriosclerosis, the internal elastic lamina is often well preserved. The medial coat shows slight fibroblastic infiltration. In the acute stages, aggregations of lymphocytes, leukocytes and giant cells may be seen. Extensive fibroblastic proliferations may also be observed in the adventitia, with foci of lymphocytes around the vasa vasorum. The lesions in the vein resemble those in the artery. The extensive proliferation of endothelial and fibroblastic cells constitutes the most striking histologic feature of the lesion, and the end stage of the process consists of dense perivascular fibrosis binding the artery, vein and nerve into a fibrous cord, and a true thrombus undergoing organization and recanalization, occluding the vessel.

As a consequence of these pathologic changes and the resultant arterial obstruction, the arterial blood flow through the extremity is decreased. This constitutes the underlying physiologic disturbance in the disease and the basis for most of the clinical manifestations. As in arteriosclerotic occlusive disease, the extent of this impairment of circulation is dependent upon several factors, including



*Figure 260.* Posterior tibial artery and vein. The artery is occluded by an organized thrombus. Periarterial and perivenous fibrosis is marked.

particularly the level, extent and rapidity of development of the occlusive process, and finally upon the development of collateral blood flow. Still another important factor is the degree of arteriolar spasm, which is often so severe as to produce manifestations resembling Raynaud's phenomenon.

*Symptoms and Signs.* The clinical manifestations of thromboangiitis obliterans are attributable primarily to impairment of the arterial blood supply to the tissues. Accordingly, they are similar in many respects to those of arteriosclerotic occlusive disease of the extremities. Pain is the chief and most common complaint. Although it may vary in type, it usually takes the form of intermittent claudication, especially in the earlier stages of the disease. The patient usually complains of cramping pain in the calf muscles or foot, but in some instances the complaint is of a sense of undue fatigue rather than pain. In more advanced cases with severe ischemia, rest pain is a prominent feature and is usually localized in the foot or toes. It is more severe at night, is aggravated by cold, and may be somewhat relieved by dependency. The pain due to ischemic neuritis, which is also encountered, is an indication of an extensive occlusive process. As in arteriosclerosis, the pain is stabbing and burning and may be associated with paresthesia. It is often paroxysmal, extremely severe, and associated with manifestations of Raynaud's phenomenon, such as definite blanching, cyanosis or mottling of the skin of the part, and excessive sweating. In the later stages of the disease, when ulceration and gangrene have occurred, the pain is usually more severe, persistent, and more intense at night. Pain may also occur in lesions of superficial thrombophlebitis, which may be present in thromboangiitis obliterans, but it is usually not severe.

Examination usually reveals evidence of chronic arterial occlusion. Since these patients are usually in the younger age groups and the occlusive process involves more peripheral vessels, the changes in the skin and soft tissues are generally less pronounced than in arteriosclerosis. There is also a greater tendency toward involvement of the upper extremities and toward the occurrence of vasospastic phenomena in thromboangiitis obliterans.

In the early stages of the disease, there may be little cutaneous discoloration, and ulceration and gangrene are uncommon. In the more advanced cases, however, rubor of the skin is evident and vasoconstrictive phenomena are common, producing color changes simulating those of Raynaud's phenomenon. The color sequence of pallor, cyanosis and rubor appears after exposure to cold, but unlike Raynaud's phenomenon these changes are usually asymmetric. Even in moderately advanced cases, postural color changes are usually observed and the time required for venous filling is abnormally prolonged. Coldness of the affected part can usually be readily detected by simple palpation. Even in the same extremity, certain digits may be cooler than others.

One of the most characteristic findings is impairment or absence of peripheral arterial pulsations. This is true in a great majority of cases once manifestations appear. Most frequently involved are the posterior tibial and dorsalis pedis arteries. The radial and ulnar vessels may be affected; indeed, it has been estimated that this occurs in about one-third of the cases. In this connection, patency of the ulnar artery, which is frequently not palpable, can be determined by Allen's test. This is performed by having the patient extend his hands in front of the examiner, who places one thumb lightly over each radial artery. The patient is then asked to clench his fist as tightly as possible for about 10 or 15 seconds in order to squeeze the blood out of the hand, following which the examiner compresses the radial and ulnar arteries by pressure with his fingers. The patient is then asked to open the fist and extend his fingers, and the return of color to hands and fingers is observed as compression of the ulnar artery is released and the radial artery is maintained. Normally, the pallor in the hands and fingers is quickly replaced by a normal or

higher than normal degree of color. On the other hand, if the ulnar artery is occluded the pallor remains for a prolonged period. To determine whether or not the radial artery is occluded the test is repeated with compression of the ulnar artery and release of the radial artery as the fist is opened.

Localized or migratory superficial thrombophlebitis is not uncommon in thromboangiitis obliterans, developing at some stage of the disease in about 40 per cent of patients. In some instances it may antedate the symptoms of occlusive arterial disease by months or even years. These lesions, when they involve the superficial veins, usually appear as red, tender, indurated cords varying from a few millimeters to several centimeters in length. The acute manifestations usually disappear in several weeks, leaving only a firm, nodular, cordlike area. They are often migratory, appearing in different parts of the extremities. The presence of such lesions in association with definite manifestations of occlusive arterial disease is almost pathognomonic of thromboangiitis obliterans.

In more advanced cases, edema of the peripheral parts of the extremities, especially of the toes and feet, is fairly common and is usually indicative of severe degrees of ischemia. Ulceration and gangrene, also frequent manifestations of the more advanced stage of the disease, are most commonly encountered near the tips of the digits and about the margin of the nails and are often precipitated by trauma. These lesions are characteristically painful and tender. As a result of secondary infection, the surrounding tissues may appear red and swollen with manifestations of cellulitis.

It should be realized that considerable variations exist in the clinical manifestations and course of the disease. In many cases the disease is episodic and only slowly progressive, with periods of exacerbations and remissions during which symptoms may improve. Occasionally, however, it is exceedingly acute at onset and fulminating in its course, with rapid progression to gangrene that may require amputation of the extremity. Other variations in the clinical course of the disease may be recognized between these two extreme forms of the process.

*Diagnosis.* The diagnosis of thromboangiitis obliterans is based on the characteristic clinical manifestations with objective evidence of occlusion of the peripheral arteries in relatively young patients, usually men who are habitual smokers. The presence of superficial

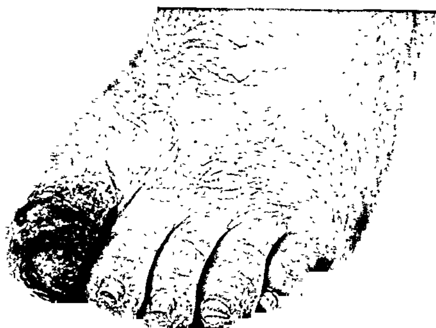


*Figure 261.* Gangrene of the dorsum of the left great toe due to thromboangiitis obliterans.

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segmental occlusive disease may be more effectively treated by direct surgical procedures designed to restore normal circulation, it is essential to determine precisely the location and extent of the occlusive disease in all such cases. For this reason angiography is an important diagnostic procedure in these patients.

*Treatment.* With regard to treatment of thromboangiitis obliterans, it should be recognized first that since the etiology of the disease is unknown, no specific cure exists. Although in general the principles of treatment are similar to those previously described for arteriosclerosis obliterans, certain factors underlying management of this disease deserve emphasis. For one thing, the disease tends to occur in relatively young persons, whose capacity for repair and development of collateral circulation is generally better than that of older patients with arteriosclerosis. Furthermore, the episodic character of the disease, with periods of remission, provides opportunity for development of collateral circulation and more effective therapy if carefully carried out. Finally, there is often a greater tendency toward arteriolar spasm and consequently greater capacity for vasodilatation under appropriate therapy.

As in arteriosclerosis obliterans, the objectives of treatment consist essentially in elimination or avoidance of these factors which contribute to progression of the disease and institution of certain measures designed to improve the circulation of the part. These measures need not be considered here since they have been previously described in detail in the section on arteriosclerosis obliterans. They include, particularly, education of the patient concerning the nature of the disease and care of the extremities, especially proper foot hygiene, and avoidance of trauma and factors that produce vasospasm. In this connection, emphasis is again placed upon the importance of discontinuing tobacco smoking. Indeed, in no other peripheral vascular disease is this relationship more important. This cannot be too strongly emphasized, because therapy, no matter how meticulously carried out, cannot be effective unless the use of tobacco is permanently abandoned.

As in arteriosclerosis obliterans, sympathectomy is the most effective means of improving the local circulation of the part. Because the vasospastic component of the disease is often pronounced, the effects of sympathectomy may be more striking than in arteriosclerosis obliterans. It is particularly beneficial to patients who have the slowly progressive form of the disease with relatively mild or moderate degrees of pain and gangrene. Results are much less satisfactory when sympathectomy is performed in the acute fulminating and rapidly progressive type of the disease, which fortunately is relatively uncommon but which unfortunately responds poorly to all forms of treatment.

### ACUTE ARTERIAL OCCLUSION (THROMBOSIS AND EMBOLISM)[47-57]

Sudden occlusion of the arteries of the extremities results from thrombosis or embolism. Acute arterial thrombosis is usually superimposed on an underlying arteriosclerotic process. Less frequently it occurs in thromboangiitis obliterans and rarely in periarteritis nodosa, certain infectious diseases and blood dyscrasias. Acute arterial thrombosis may also result from trauma to the extremities, such as crushing injuries, fractures and lacerating injuries which produce contusion of the vessel wall. Most arterial emboli originate in the heart from an auricular thrombus due to fibrillation, from a ventricular thrombus following myocardial infarction, and from vegetative disease of the aortic or mitral valve. Less commonly, an atherosclerotic plaque may be broken off from the wall of the aorta or other major arterial trunk and lodge in a peripheral vessel to produce sudden occlusion and thrombosis.

The vessels of the lower extremities are most frequently involved, both in acute thrombosis and in embolism, with the highest incidence in the femoral artery and the next highest in the popliteal and iliac arteries. The upper extremities are involved in 15 to 20 per

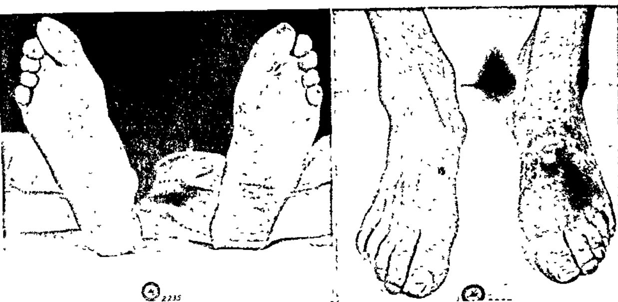


*Figure 262.* Thromboangiitis obliterans with pregangrenous change involving the dorsum and plantar surface of the left foot Deep venous thrombosis preceded symptoms of arterial disease by four months



*Figure 263* Raynaud's phenomenon in a patient with thromboangiitis obliterans. The tips of the second, third and fourth fingers are ulcerated or scarred from previous ulcers

thrombophlebitis or an adequate history of such lesions, the asymmetric nature of the process and progressive involvement of each of the extremities, including particularly the upper extremities, are additional clinical criteria in favor of the diagnosis. The major difficulty in differential diagnosis is encountered in patients in whom evidence of chronic occlusive arterial disease develops during or after the fifth decade. Under these circumstances, unless other supporting evidence can be provided, it may be difficult to determine whether or not the underlying process is thromboangiitis obliterans or arteriosclerosis obliterans. Important criteria in the differential diagnosis of thromboangiitis obliterans are its rare occurrence in women and nonsmokers and its usual development in relatively young men in the third and fourth decades of life. Recent studies, however, have clearly demonstrated the fact that in some patients with all the characteristic clinical and physical findings of thromboangiitis obliterans the underlying process is arteriosclerosis obliterans, producing segmental occlusion of the iliac or femoral arteries. Since patients with this form of

age groups. Involvement of the lower extremities is associated with a higher incidence of gangrene of the part and fatal outcome than that of the upper extremities. In general, the more proximal the occlusion, the more serious are the consequences. Thus, occlusion at the site of the aortic bifurcation or in the iliac arteries results in gangrene in more than half the cases, whereas this complication follows occlusion of the femoral artery in only about one-third of the cases. Even with survival of the part, varying degrees of arterial insufficiency may persist, resulting in intermittent claudication, residual temperature and color changes, and ischemic neuritis.

*Diagnosis.* The characteristic signs and symptoms of acute arterial occlusions previously mentioned usually permit ready recognition of the condition. It should be recalled, however, that in some patients the manifestations are not sudden or dramatic in onset but develop gradually over a period of hours. The major difficulty arises in differentiation between acute thrombosis and embolism. The former is more likely in the presence of pre-existing arterial occlusive diseases, such as thromboangiitis obliterans and arteriosclerosis obliterans, acute infections and trauma, whereas the latter is more likely in the presence of cardiac disease. Determination of the presence or absence of a source of emboli constitutes the essential basis for this differentiation.

*Treatment.* The objective of therapy for these lesions is immediate restoration of blood flow to the tissues distal to the occlusive process, embolic, traumatic or thrombotic, superimposed on an arteriosclerotic process. Although the operative procedure may vary according to the cause and nature of the process, success is dependent in great measure upon the promptness with which therapy is instituted. Regardless of the nature of the lesion, obstruction is sudden, and collateral circulation under these circumstances is frequently inadequate to provide sufficient blood flow in the distal segment to prevent extension of occlusion by thrombosis and irreversible ischemic damage to the involved part. Prior to the development of these undesirable complications, the lesion is localized to a relatively short segment of artery, and during this stage of the disease normal blood flow may be restored by operation directed toward the lesion itself. Traumatic lesions may be treated by simple suture, excision and graft replacement, or end-to-side bypass graft depending upon the type and extent of injury. Arterial emboli are removed from the artery by incising the vessel and removing the embolic material. Circulation is then restored by simple suture of the arterial wound. A thrombus may extend for a variable distance beyond the embolus in some patients with embolic obstruction, particularly when therapy has been delayed. This distal thrombus or "tail clot" may be removed by massage toward the arterial opening made to remove the embolus or by retrograde flush through a cannula inserted into the artery distal to the thrombus. Occlusions resulting from thrombus superimposed on an arteriosclerotic lesion may be treated by thromboendarterectomy, excision and graft replacement, or bypass graft as previously described.

The occlusive process may be diffuse in some patients or the general condition of the patient may not permit operation. Under these circumstances treatment is nonsurgical. Conservative measures include medication for relief of pain, proper care of the extremity, production of vasodilatation in the part, and use of anticoagulant therapy. Although body warmth should be maintained at about normal room temperature, heat should not be applied locally to the extremities. The involved extremity should be wrapped loosely, but voluminously, in cotton batting, and its position should be maintained just below heart level by elevation of the head of the bed. Every effort should be made to provide maximal vasodilatation in the affected part by interruption of vasoconstrictor impulses transmitted over the sympathetic pathways. These vasoconstrictor impulses may or may not be excessive, but their abolition increases the volume of the

cent of the cases, with the highest incidence in the brachial artery and the next in the axillary artery. The aortic bifurcation is the site of involvement in 5 to 10 per cent of cases.

Although acute arterial occlusion may occur at any age, it is most frequently encountered in the fifth to the seventh decades, less than 10 per cent of the cases occurring in patients younger than 30 years of age. Most observers have found a slightly greater frequency among female than male patients

*Pathologic Physiology.* The chief disturbance in sudden arterial occlusion is acute ischemia of the tissues, the viability of which then becomes dependent upon establishment of adequate collateral circulation. This, in turn, is dependent upon several factors including particularly the site and extent of the occlusion, the degree and extent of vasospasm, and the occurrence of secondary thrombosis. In general, when the occlusion occurs at the sites of major arterial bifurcations, the degree of ischemia is much more severe, owing to occlusion of important collateral branches arising from them. On the other hand, occlusion of arterial segments that are relatively free of collateral branches, such as the external iliac and superficial femoral arteries, may produce less serious ischemic manifestations, since the collateral branches situated proximal and distal to the point of occlusion may provide sufficient blood flow to maintain viability of the tissues. In addition to the mechanical blockage of the arterial lumen, acute arterial thrombosis and embolism may be associated with severe and widespread vasospasm involving both the distal segment of the artery and the collateral branches, with further diminution in the blood supply to the part. This vasospasm is believed to be of reflex origin, being initiated by stimulation of the sensory fibers in the arterial wall at the site of the embolus. Still another factor that may increase the degree of ischemia, and consequently the danger of gangrene, is the occurrence of secondary thrombosis both proximal and particularly distal to the embolus or the original thrombus. Retardation in blood flow resulting from decrease in arterial pressure below the site of occlusion and the associated widespread vasospasm, which, if prolonged, may produce changes in the intima of the vessel, are believed to be the main factors responsible for the production of the secondary thrombosis. The clinical manifestations of acute arterial occlusion are fairly characteristic, although there may be some variations, depending upon several factors, including particularly the nature and extent of the process, the age of the patient and the underlying disease. In the majority of cases onset is abrupt but may occasionally be more gradual, requiring several hours for the symptoms to develop. The initial symptom is usually severe pain in the involved extremity, often followed immediately by numbness and tingling and later by muscular weakness and even paralysis of the extremity. The pain is usually experienced near the site of involvement, although it may shift distally later. In perhaps one-fourth or more cases numbness, coldness and tingling precede the pain. Objective findings include absence of arterial pulsations distal to the site of occlusion, temperature and color changes, loss of muscular power, loss of sensation and diminished reflexes. Absence of arterial pulsations, one of the most important signs, is helpful in determining the site of occlusion. The characteristic color and temperature changes are pronounced pallor, or a mottled cyanosis, and coldness of the part. Collapse of the superficial veins in this region also constitute a characteristic change, the occurrence of which depends to a great extent upon the site of the occlusion.

The clinical course of arterial occlusion is variable, depending upon a number of factors, including particularly the site and extent of the occlusive process, the duration of occlusion before institution of treatment, and the general condition of the patient, especially the severity of the underlying disease. The age of the patient is also important, with a higher incidence of gangrene of the part and death of the patient in the older

environment in some of the shelters, particularly those underground, is believed to have contributed to development of the edema. Knight considered shelter leg a form of trench foot in civilians.

*Immersion Foot.* Immersion foot is another form of cold injury which follows prolonged immersion of the feet and lower legs in cold water, although it has also been observed after exposure in subtropical waters. Ungley[67] has described it as "peripheral vasoneuropathy after chilling." The condition, which is clinically and pathologically similar to trench foot, occurs characteristically in shipwrecked sailors, who are either in the water or in life rafts or boats with their feet dangling in cold water for a considerable time. It usually occurs in association with dependency and immobility of the lower extremities and with constriction of the limbs by clothing and shoes. Inadequate clothing, body cooling and nutritional deficiency probably contribute to its development. Clinical manifestations include swelling of the lower feet and legs, numbness, tingling, itching, pain, cramps and cutaneous discoloration. Three stages of the condition are generally recognized: (1) a prehyperemic stage, lasting from a few hours to a few days, characterized by coldness, numbness, swelling and discoloration of the extremities; (2) a hyperemic stage, of 6 to 10 weeks' duration, manifested by tingling or pain, motor disturbances, temperature differentials of the skin, increased swelling, blister formation, ulceration and sometimes gangrene; and (3) a posthyperemic stage, lasting for weeks or months.

*Trench Foot.* Trench foot, a term which originated during World War I, is a form of cold injury involving the lower extremities. Its clinical manifestations are similar to those of immersion foot. Other terms used during World War I include boot bite, puttee bite, cold bite, cold injury, water bite and trench bite. Trench foot commonly oc-



*Figure 264.* Gangrene of the feet due to frostbite. Exposure occurred about one week previously.

peripheral vascular bed and thus augments the volume of circulating blood to the part. This is best achieved by interruption of the sympathetic impulses with a 1 per cent solution of procaine hydrochloride. Under certain conditions in which a permanent effect is desired, and in which there is no contraindication to operation, sympathectomy is advisable. The use of anticoagulants is considered a valuable adjunct in controlling the extension of thrombosis in the collateral tributaries as well as in the involved arterial segment. These agents may be employed for this reason in patients with embolic occlusion or in patients with thrombosis. Anticoagulants should not be employed in patients who have recently sustained traumatic lesions because of the likelihood of producing secondary or recurrent hemorrhage.

### COLD INJURY[58-63]

The term "cold injury" is considered preferable to other terms because it is more inclusive for the various conditions resulting from exposure to cold. Because of differences in mode of development, clinical patterns and severity of tissue injury, various descriptive terms have been used for this purpose, such as chilblain, frostbite, trench foot and immersion foot. In all these conditions, however, the physiologic and pathologic responses of the body to cold are essentially the same, the major difference being due chiefly to the degree of injury, which, in the final analysis, represents the total heat loss of the part. Most important of the factors determining the amount of heat loss are the degree and duration of exposure and the rate of heat loss of the part, which is determined by the surrounding conducting medium. Thus, prolonged exposure to relatively mild degrees of cold, above freezing for example, in a moist environment, such as exists in trench foot or immersion foot, may produce severe tissue injury with resultant gangrene. On the other hand, relatively short exposure to much more severe degrees of cold, well below freezing, in a dry environment may produce actual freezing of some of the tissues, as in frostbite, but little or no tiss necrosis. Whereas in the former instan the degree of cold is much milder th in the latter, the amount of tissue inju is greater because of greater total he loss of the part. Thus, such specific terr as frostbite, trench foot and immersi foot do not necessarily signify differe degrees of injury but, instead, represe different modes of development. In t majority of cases, too, they assume som what different clinical patterns. For th reason and because of common medic usage, it is desirable to define these sp cific terms.

*Chilblain.* Chilblain is a relative mild form of cold injury encounter most frequently in moderately cold c mates with high humidity. It is usual seen in the hands of outdoor worker particularly on the dorsal surface, b may also affect the lower extremitie especially the anterior tibial surface the legs of young women. The conditio may be acute or chronic. The chron form, which occurs after repeated e posure, is also known as erythrocyanosi Bazin's disease, pernio or dermatitis hi malis. The acute form is usually man fested by a bluish red appearance the skin and mild edema, often associate with an itching or burning sensatio which may be aggravated by warmth. exposure is brief, these manifestatior may completely disappear with no resi ual sign. Intermittent exposure, on th other hand, results in development c chronic manifestations. There may b increased swelling, deep reddish purpl discoloration of the skin, blisters an hemorrhagic ulcerations, which hea slowly to leave numerous, permanen pigmented scars.

*Shelter Leg.* Shelter leg is another rela tively mild form of cold injury involvin the lower extremities. Its name is de rived from the fact that it was encountered in England during the blitz of 1939–1940 in people who were sitting in air raid shelters most of the night or sleeping in a sitting position with their legs crossed or hanging down from a chair. It was more commonly seen in elderly or obese persons. The cold, damp

One of the major effects of exposure to cold on the vascular system is greatly increased permeability of capillary walls, which is likely to occur during the red or hyperemic stage after exposure has terminated and thawing or re-warming has been effected. As a result, there is transudation of plasma through the vascular wall, with deceleration of the flow of blood through the minute vessels. When plasma passes through the vascular walls, the blood cells remain tightly packed in the lumen, mechanically preventing further flow of blood through them. Kreyberg attributes this phenomenon of occlusion of the small vessels to true stasis and not to intravascular coagulation. Others, however, believe that true agglutinative thrombosis takes place. Although the initial edema of cold injury may be ascribed to outpouring and drainage of tissue fluids, an inflammatory factor is believed to be added as capillary permeability increases; this is the sterile or aseptic inflammation characteristic of further local response to cold. The reaction to severe or prolonged cold, according to Kreyberg, is solely the result of acute aseptic inflammation from tissue damage caused by the lower temperature, the freezing to ice and the deprivation of oxygen. He considered this aseptic inflammatory reaction to be primarily a vascular response and not direct injury responses to cold. He defined acute aseptic inflammation as the combined local vascular and cellular reaction subsequent to the introduction of an element foreign to the tissues. Lewis ascribed this inflammatory reaction to release of a histamine-like substance in the damaged tissue. Kreyberg, on the other hand, believed that the devitalized and damaged tissues and the abnormal metabolic products may act as foreign elements and that either a cellular or a vascular type of reaction may predominate, depending upon the extent of the tissue damage.

Ariev compared the response of the tissues to cold to a chemical reaction in which the speed of the reaction is proportional to the temperature at which it takes place. Accordingly, although injury from frostbite, for example, would occur early, it would become manifest only when the temperature of the injured part was raised. The behavior of cold injuries would seem to support this hypothesis. Predominant early clinical features include pallor, edema and numbness. When the part is warmed, the arterial circulation increases rapidly, whereas in the later stages of hyperemia, which is both reactive and inflammatory, blister formation, necrosis and actual gangrene appear according to the severity of the injury. These latter processes, however, remain latent because of the retarding effects of cold, becoming manifest only when the injured part is warmed. If the injury is superficial and the underlying tissues are not devitalized, the involved parts which seem seriously damaged may be restored to normality.

*Pathology.* Pathologic changes in cold injury depend upon the duration and degree of exposure. The responses are basically inflammatory and degenerative, involving primarily the skin, subcutaneous tissue, muscles, nerves and blood vessels, although degenerative changes in body structure and joint tissues have also been observed.

Microscopically, the most pronounced changes occur in the blood vessels. These include dilatation of the vascular lumen, which contains a certain amount of fibrin deposits, swelling of the endothelium of the intima, vascuolization of the muscle fibers of the intima and increase in the number of cells in the perivascular tissues. The lymphatic vessels appear normal or dilated, depending upon the extent of injury, and may be filled with masses of fibrin, although the walls often remain unaffected. The tissue spaces are filled with a copious deposit of fibrin threads and granules. The collagen bundles of the fibrous tissue may be separated, swollen and undergoing dissolution in the exudate. If the edema is of long standing, the swollen tissues show diffuse lymphocytic infiltration. Extravasation of the erythrocytes is presumably the result of sudden congestion of the damaged circulation during the reactive hyperemic stage. The nerves of

curs under combat conditions when immobility is forced by enemy action and when circumstances make adequate foot care difficult or entirely impractical.

*Frostbite.* The term "frostbite" should probably be limited to cold injuries in which there has been actual freezing of cutaneous and subcutaneous tissue. Evidence of such freezing, however, is often difficult to establish. The condition is generally regarded as a response to more severe forms of exposure to environmental temperatures at or well below the freezing point of water. It may also occur following prolonged exposure to temperatures near or just below freezing or brief exposure to extremely low temperatures, such as was observed in World War II, chiefly in flyers, in the form of high altitude frostbite. Exposed portions of the body, such as the fingers, ears, nose, chin, cheeks, forehead and feet are most frequently involved. Thus, frostbite may develop suddenly in unprotected parts directly exposed to extremely cold or windy weather or to cold metal. It may develop insidiously following prolonged exposure even of protected parts. The patient complains first of a local burning or stinging sensation followed by numbness. The skin assumes a grayish or whitish waxy appearance. Sometimes all involved tissues are extremely hard and fixed, or the affected part may have the appearance of a small superficial plaque-like area. After the area has been thawed, there appears a stage of reactive hyperemia of varying intensity, depending upon the degree and duration of exposure and the extent of tissue injury. This consists in local reddening and the appearance of a blister or a blister and a wheal. In more severe cases, secondary thrombosis of arterioles and capillaries, with regional anoxia and cyanosis, may progress to gangrene.

*Pathogenesis.* Maximal response to cold is exhibited by the vascular system. The first reaction of the skin to cold is vasoconstriction or blanching. All surface vessels, including arteries, arterioles, capillaries and venules, are believed to be involved in the mechanism of vasoconstriction, which is regarded as a total response by the body to prevent loss of heat. According to Lewis,[61] vasoconstriction resulting from cold is not a simple reaction but involves three separate components: (1) the direct and persistent response of the superficial vessels in the form of local contraction; (2) transient, general vasconstriction brought about by a reflex action through the central nervous system; and (3) persistent general vasconstriction, probably caused by the return of cold venous blood from the cool skin and consequent lowering of the temperature of the general circulation. According to Kreyberg,[62] at skin temperatures of 77° to 59° F., cyanosis appears as a result of local oxygen deficiency, and the skin is cold to touch. Progressive lowering of the temperature causes other color changes. The skin becomes bluish red at a temperature of about 59° F. (15° C.), reddish purple or red at about 50° F. (10° C.), and below that level a bright pink, the last stage being associated with pain. Once the bright pink stage is reached, the alternating constriction and dilatation described by Lewis begins to occur. The cutaneous temperature may rise temporarily. The pink color is attributable to the presence of blood in the minute regional vessels, which remain constantly dilated during this stage. The sensation of cold is lost, with further reduction in tactile and pressure sensibility. With exposure to even lower temperatures, however, these minute vessels again contract, resulting in a second white stage, which should not be confused with the white, waxy stage caused by actual freezing of tissues, presumably due to ice crystallization.

In all the foregoing circumstances the reactions which occur are chiefly physiologic and reversible, if environmental temperatures return to normal. Prolonged exposure, however, may cause progression of the process to actual pathologic damage of the tissues. Thus, protracted exposure to even moderate degrees of cold may result in severe tissue damage, whereas additional exposures to lower temperatures may produce actual freezing of the skin and tissues.

common, and intracutaneous ecchymosis is more severe. Pain may be intense during this stage. The circulation may or may not be adequate, but in this more severe form of cold injury if the circulation is arrested and gangrene develops, the skin assumes a dry, firm, discolored appearance.

When the edema subsides, manifestations of the posthyperemic stage appear. These also depend upon the severity of the original injury; in mild cases there may be only desquamation with little or no loss of tissue, whereas in more severe cases the ecchymotic areas turn black and become hard and mummified, suggesting dry gangrene.

The clinical manifestations of immersion foot and trench foot may also be conveniently described according to the three stages: prehyperemic or ischemic, inflammatory or hyperemic, and posthyperemic. During the first stage the feet are cold, wet and numb with variable degrees of pallor and purple mottling. There is little or no swelling. Walking may cause a sensation of pins and needles. The ischemic or preinflammatory stage, which occurs when exposure is terminated, usually lasts only a few hours after the shoes are removed and the feet are dried. The inflammatory or hyperemic stage then begins. This is manifested by swelling of the feet, which become hot, dry, red and painful, exhibiting all the signs of acute inflammation. When the feet first begin to warm, the patient complains of tingling pain. As they become warmer, burning and even throbbing pain develops. External heat is often intolerable in this stage, the feet being most comfortable when exposed to a cool temperature. Clinical progression during this stage may be correlated with the severity of the injury. In the mildest cases, inflammatory signs reach a maximum during the first 24 hour period, after which they rapidly subside. In more severe cases, this acute inflammatory process does not begin to subside for 48 to 96 hours. In severe cases at the height of the inflammatory process, usually between the fourth and sixth day, the edema may extend to the knees. With regression the edema begins to disappear, and finally the skin wrinkles. The original bright red color turns first brownish and then fades. Exfoliation usually occurs, leaving the skin delicate and waxy. In extreme cases, blisters develop, and signs of circulatory insufficiency become apparent early in the second stage, when the shoes are first removed. The blisters contain fluid which is usually clear but sometimes hemorrhagic. Areas of superficial thrombosis may be seen. In some cases impending gangrene progresses to frank gangrene within 48 hours. Small areas of redness and induration may appear on the skin of the feet during the first week of the inflammatory stage. These are acutely tender to touch, and their appearance suggests the presence of cellulitis. The inflammatory process may be enhanced by secondary infection, especially in the presence of blister formation and actual tissue necrosis. At the end of the first three weeks edema may persist in a small proportion of cases, depending on the extent of injury. As it disappears, the feet become moist instead of dry.

The posthyperemic phase begins as the edema and acute inflammatory signs subside. The abnormally high temperature of the feet disappears more rapidly than the edema. At the end of a week only rarely do the feet remain extremely hot. After one to three weeks, however, in some patients there is extraordinary variability in temperature of the feet. Even under observation, the feet may change within a few minutes from warm and dry to cold and wet or the reverse. The patient is often awakened by a burning sensation in his feet. In mild cases, the acute pain may disappear by the end of the first week, leaving the foot comfortable thereafter. More often, the original burning pain is replaced by a deep-seated ache in the ankle and transverse and longitudinal arches. The pain is usually worse at night and resembles the aching pain of rheumatoid arthritis. Ambulatory patients complain of pain in the weight-bearing parts of the foot. Late in the postinflammatory stage, pain may be associated with thickening and stiffening

the affected area manifest axis cylinder swelling. There may be no degenerative nerve changes unless the injury is severe, in which case degenerative and, later, regenerative changes may ensue. In protracted cases, leukocytic infiltration, edema and fibrin deposition may be present between the fibers.

According to Friedman, the edema in cold injuries such as trench foot and immersion foot involves the skin, subcutaneous tissues, nerves and muscles. Cellular exudates in the epidermis and subcutaneous tissues are less pronounced than in the immediate vicinity of the congested vessels. The rete pegs become smooth, and the sweat glands show atrophy, degeneration, cystic dilatation and vacuolization. There is leukocytic infiltration of adipose tissue in the area of injury, involving the deeper subcutaneous regions and those around the appendages even when the overlying layers do not appear greatly affected. In late stages fat lobules become diffusely infiltrated with foam cells laden with finely divided fat. Fibrous replacement of adipose tissue may be pronounced in some of these cases.

In the early stages the vascular tree is greatly engorged and extravasation of red blood cells typically surrounds the engorged plexuses. Numerous vessels contain agglutinative erythrocytic thrombi of the type found in stagnant blood rather than a freely moving blood stream. Mural hemorrhage and inflammation may be observed in both patent and plugged vessels and many vessels are greatly constricted. Transition from thrombosis to endarteritis obliterans may occur at any later phase. Connective tissues and capillaries may exhibit proliferation and development of a mucinous stroma. Also at later stages angiitis obliterans may be present in both arteries and veins, even in practically normal tissues well above the line of demarcation. It may vary from slight thickening to obliteration of the lumen, a late manifestation of the pathologic process. Slightly involved arteries often show subintimal cellular proliferation with mucinous and edematous matrix.

In the early stages, the muscles show degeneration, necrosis and cellulitis. Later atrophy may be extensive. Necrosis and inflammation are evident in gangrenous areas. The degree of cellulitis varies, of course, depending upon the extent of secondary infection.

The earliest pathologic alteration in the nerve is the development of edema with varying degrees of hemorrhage. In advanced stages, demyelinization is observed at all levels but is usually more extensive below the zone of demarcation. Between the nerve fibers are often many foam cells containing sudanophilic material in fine droplets, presumably from broken-down myelin. Later degenerative changes appear in the axis cylinders as well, and some nerve bundles exhibit edema and separation of the fibers and, occasionally, actual increase of endoneural connective tissue elements.

*Clinical Manifestations.* The symptoms and signs of cold injury depend upon the degree of cold, duration of exposure, and extent of tissue damage. Initially, the patient complains of numbness, tingling, coldness of the part and a wooden feeling of the injured parts. Muscular action becomes increasingly difficult. During this ischemic stage, the appearance of the skin ranges from waxy pallor to grayish purple mottling, depending upon the degree of injury. There is little or no swelling.

With thawing or rewarming of the part, the manifestations of hyperemia appear. The symptoms and signs during this stage depend upon the degree of the initial injury. In first degree frostbite, for example, often associated with a stinging or burning pain, moderate edema may develop, followed later by some superficial desquamation of the skin. In second degree frostbite, in which the foregoing symptoms may be more pronounced, blisters and even intracutaneous ecchymosis may also develop, but healing usually takes place without ulceration. In third and fourth degree frostbite, the injury is more extensive, with involvement of all areas of the skin and even of subcutaneous tissue. Edema is more pronounced, blister formation is

be responsible for the vascular lesions. Clinically, the absence of any known allergy to drugs or other sensitizing agents in many cases casts doubt on this theory.

The essential pathologic changes of periarteritis nodosa consist first in the characteristic vascular lesion and second in the resultant ischemic effect upon the tissues and organs involved. The process begins in one or all of the coats in a short segment of the artery. Generally, only one part of the circumference of the vessel is involved. In small arteries the polymorphonuclear infiltration is usually localized just beneath the intima, whereas in larger vessels the lesion is located primarily at the junction of the elastic media and the adventitia. Destruction of the elastic fibers of the media and particularly the internal elastic membrane results in weakening of the vessel wall and aneurysms may develop. In the smaller arteries and arterioles where the intima is involved, thrombosis may take place. The process may be found in different stages in arteries widely scattered throughout the body. Most commonly, the vascular beds in the kidney, heart and lungs are involved and less frequently, those of the liver and nervous system. Because of this pathologic picture and the widespread distribution of the involved vessels, Allen has suggested the term "disseminated microarteritis."

The symptoms of periarteritis nodosa vary with the system involved. Initially, it appears to be an acute infectious process with fever, leukocytosis, eosinophilia, abdominal pain, edema of the lower extremities, albuminuria, hematuria and loss of weight. Whenever hypertension develops, the process closely resembles acute glomerular nephritis Pain in the lower extremities, neuritic in type, and symptoms suggestive of cardiorenal disease are commonly encountered. The muscles of the hands and feet may become painful and the joints may be involved. Nodules develop about the subcutaneous arterioles and are frequently palpable. They are usually single, varying from 1 to 10 millimeters in diameter, and are hard, movable and tender. Arteriolar involvement may result in symptoms resembling those of Raynaud's disease. When smaller arteries become occluded by thrombi, the symptoms may simulate those of thromboangiitis obliterans. In some instances, the peripheral vascular manifestations become severe enough to require amputation of the extremity.

The diagnosis of periarteritis nodosa is seldom made before death, because of its protean nature. The diagnosis can be established from biopsy provided the specimen of tissue is removed from the area of involvement. In the absence of subcutaneous nodules or areas of tenderness, this may be difficult. The differentiation of peripheral vascular symptoms due to periarteritis nodosa and those caused by primary peripheral vascular diseases is not generally difficult, the systemic manifestations of the former providing the clue to the correct diagnosis.

The treatment of periarteritis nodosa is not satisfactory. Recently, ACTH and cortisone have been used in the therapy of this disease and in some instances healing of the lesions occurs following institution of hormone therapy. Although they are not curative, these agents appear to prolong the life expectancy of the patient with periarteritis nodosa.

### Disseminated Lupus Erythematosus

This is a chronic, ultimately fatal disease that occurs predominantly in females before the age of 40. The pathologic lesions consist of involvement of the serous membranes, splenomegaly, lymph node enlargement and endocardial lesions. Changes may be found also in the viscera. From 15 to 20 per cent of patients with disseminated lupus erythematosus will have focal tuberculous involvement of the lymph nodes. Microscopically, a variety of lesions may be found. The principal changes seem to occur in the collagenous connective tissue and are both proliferative and degenerative. Varying degrees of leukocytic infiltration occur, lending an inflammatory nature to the lesions. The characteristic histologic change is the fibrinoid

*about the joints. Some feet may appear* entirely normal upon examination, but others may exhibit general atrophy of structures. Hyperesthesia and anesthesia may persist, and hyperhidrosis may be severe. Hyperesthesia and paresthesia may subside but anesthesia is the last *sign to disappear, lasting as long as 6* months.

*Treatment.* Although some controversy exists regarding specific measures proposed in the treatment of cold injury, certain general principles of treatment appear to be well established. These include, initially, *prompt restoration and* maintenance of general body warmth and protection of the injured parts from further trauma. The involved area should not be massaged or rubbed. If the feet are involved, the patient should be confined to bed and the feet kept exposed to a moderately cool, comfortable air temperature. The injured parts should be kept clean by daily washing with warm, soapy water and gentle drying. Blisters should be left undisturbed unless tension renders them painful. If the vesicles rupture, the dead tissue should be removed, the area cleansed and the foot wrapped loosely in a sterile towel. The toes should be kept separated by the use of sterile cotton pledgets. *Antibiotics should be administered to* patients with blisters and gangrene. Moderate elevation of the extremity may help reduce the edema. In the presence of gangrene, whether superficial or deep, conservative therapy should be employed because of the difficulty in estimating, in the early phase of the process, the ultimate loss of tissue. Clear demarcation should be allowed to take place before débridement and amputation are carried out.

Treatment in the postinflammatory stage is directed toward relief of symptoms and prevention of disabling atrophy of the injured parts. As the pain subsides and the cutaneous lesions heal, activity should be resumed gradually and exercises increased as tolerance permits. Physiotherapy and other rehabilitative measures may be employed as indicated.

## COLLAGEN DISEASES[69-83]

Of the disorders generally referred to as "diffuse collagen diseases," three are frequently characterized by symptoms suggestive of peripheral vascular disturbances: periarteritis nodosa, disseminated lupus erythematosus and scleroderma. The term "collagen disease" has resulted from observations that there is an alteration in connective tissue elements in these various disorders. The connective tissue changes may be proliferative or degenerative and either type may be associated with an inflammatory process. Periarteritis nodosa and lupus erythematosus are characterized mainly by a degeneration of the connective tissue elements, with inflammation, whereas scleroderma is characterized largely by proliferation of connective tissue.

### Periarteritis Nodosa

This disease, also termed essential polyarteritis, is a relatively uncommon disorder, involving particularly the medium sized and small arteries and arterioles. The condition was first reported by Rokitansky in 1852, and was described by Kussmaul and Maier in 1866, but until relatively recently it remained a pathologic curiosity. The disease occurs *predominantly in males in the third and* fourth decades of life, although it has been observed at all ages.

The etiology of periarteritis nodosa is not known, although some investigators believe that the disease is a form of allergy. Rich[79-81] has reported that the arterial lesions of periarteritis nodosa are dependent upon increased sensitivity of tissue to foreign substances. This conclusion was based on a series of cases of *serum sickness and other reaction to sulfa*thiazole in which lesions similar to periarteritis nodosa were found. Rich and associates also carried out experiments in which typical lesions of periarteritis nodosa were produced in rabbits by injections of foreign proteins. They concluded that the disease is a manifestation of anaphylactic hypersensitivity and that many different sensitizing antigens may

grene of the tips of the fingers may occur, necessitating amputation. The pulsations in peripheral arteries may be difficult to palpate because of the marked vasospasm and the rigidity of the tissues overlying the vessels. In some cases calcinosis occurs, consisting in focal lesions of varying size in the skin and subcutaneous tissue and composed of calcium deposits. These occur usually on the outer surface of the joints of the extremities and are often painful.

The administration of ACTH and cortisone appears to slow the progress of the disease but the ultimate prognosis is not altered. In the rapidly progressing and extensive form of the disease, death usually occurs within a few years, but in the more slowly progressive forms, patients may live for many years.

### Other Forms of Arteritis

A number of less commonly encountered forms of inflammatory and proliferative change in the smaller arteries and arterioles have been described. Included in this category are such conditions as temporal arteritis, erythema nodosum, erythema induratum or nodular vasculitis and nonspecific arteritis. The etiology of all of these conditions is unknown. Whether they represent distinct entities or simply variations in clinical and pathologic manifestations of other better understood conditions is not clear. They may occur as widely disseminated or fairly focalized lesions, affecting chiefly the small arteries and arterioles as well as the connective tissue and thus producing vascular disturbances.

#### *Temporal Arteritis*

Among the more localized forms of these diseases is that involving the temporal artery and occasionally the occipital and retinal vessels. In some instances the pathologic process is similar to that of periarteritis nodosa, whereas in others it appears distinct and characteristic. Occlusion from thrombosis or endothelial proliferation occurs along with thickening of the media and adventitia by a chronic inflammatory reaction often resembling granulomatous tissue.

Clinical manifestations consist of pain and tenderness about the temporal arteries, often associated with diffuse headaches, malaise, weakness and fever. Tenderness, redness and induration may be present along the course of the involved temporal arteries and later pulsations disappear. Blindness has been reported to occur in the late stages of the disease.

The disease seems to be self-limited, lasting a few months to less than a year, with gradual disappearance of symptoms. Occasional relapses occur and if visual involvement exists, it is usually permanent. There is no specific treatment other than excision of the involved vessel. Although this may result in dramatic relief of pain, the systemic manifestations may not be eliminated.

#### *Erythema Nodosum*

Erythema nodosum is an acute inflammatory form of vasculitis, often associated with rheumatic fever but also occurring in association with various other infections as well as certain drugs. Characteristic pathologic changes include edema of the skin and subcutaneous tissues, collections of neutrophilic leukocytes and lymphocytes about arterioles and venules, and dilatation of capillaries, with some proliferation of endothelium of the involved vessels and fibroblasts around them.

Clinically the disease is characterized by the appearance of rather firm, tender nodules of varying sizes, from a few millimeters to several centimeters, of the skin and subcutaneous tissues of the extremities, most commonly on the legs, thighs and arms, bilaterally. They vary in color from a pinkish to a purplish cyanotic hue, gradually changing to a grayish, brownish color as subsidence takes place over a period of several weeks. There is no tendency to suppuration or ulceration. During the acute period there may be some systemic manifestations of general malaise, mild fever, sore throat and joint pain.

The disease is self-limited, usually sub-

degeneration which is characterized by an amorphous appearing collagen that stains pink with hematoxylin and eosin. In the small arteries and capillaries there may be proliferative intimal changes with associated thrombosis as well as degenerative changes in the media.

The most characteristic clinical feature *is a skin lesion*, appearing as an erythematous eruption across the bridge of the nose and the malar region in a "butterfly" distribution. The skin lesions are raised, firm, and have a sharp border. Grayish white scales frequently appear on the surface. Similar lesions may be found elsewhere on the body. In addition to the skin eruptions, there may be fever, pain in the joints, pleuritic pain, loss of weight, shortness of breath and orthopnea. As the disease progresses, the constitutional symptoms become more severe and manifestations of visceral involvement are evident. Cardiovascular symptoms may occur and symptoms of heart failure may supervene.

A few patients with lupus erythematosus will present a sensitivity to cold and emotional stress which resembles closely that seen in primary Raynaud's disease. Gangrenous changes, however, are rare and alteration of peripheral pulses is infrequent.

The diagnosis is established readily in the presence of the characteristic skin eruption. In its absence, the diagnosis may be difficult. Biopsy of the involved areas will usually confirm the clinical diagnosis.

The treatment of lupus erythematosus, as with the other collagen diseases, is not satisfactory. Hormonal therapy, however, appears to benefit patients with this type of disorder probably more than those with periarteritis nodosa or scleroderma. Certainly, remissions have been noted following institution of therapy and it appears that the clinical course of the disease is altered somewhat by this type of treatment.

### Scleroderma

This disease, of unknown etiology, is characterized by focal or diffuse induration of the skin associated with vasomotor disturbances, visceral involvement and endocrine disorder.

Pathologically, there is atrophy of the epidermis with a flattening of the dermal papillae and atrophy of the dermal appendages. Fragmentation of the elastic tissue is common, and swelling, proliferation and fusion of the collagen fibers in the corium are seen. Small arteries of the corium are thickened and their lumens are narrowed. Infiltration of the vessel walls and of the skin with inflammatory cells is not common. Similar changes may be observed in the muscle, fascia and the various viscera.

Clinically, the focal form of the disease appears as indurated lesions of the skin of the trunk, neck and lower extremities. These lesions may follow the course of the peripheral nerves. This focal type of disease is of little significance since it only rarely progresses to the more diffuse form. The diffuse form of scleroderma is associated with rather definite constitutional symptoms. It may begin with involvement of the face and neck and proximal portions of the upper extremities, with vasomotor disturbances occurring late, or developing prominently at the onset of the disease with early involvement of the distal part of the upper extremities and the face. In the latter type, visceral lesions tend to occur late Fever may be present as well as edema and arthritic changes. Peripheral vascular symptoms of the Raynaud type are common in scleroderma. These consist of increased sweating, coldness, cyanosis and intermittent vasospastic manifestations. In the absence of sclerodermatous changes elsewhere, it may be impossible during this early stage to distinguish the condition from primary Raynaud's disease. As the sclerosing process develops in the skin the entire surface of the body may eventually be involved, as well as the mucous membrane of internal organs such as the esophagus and gastrointestinal tract, larynx, lungs and genitourinary tract. In some patients, for example, dysphagia becomes a prominent symptom. The tips of the fingers and toes and the nose may also appear atrophic, and ulceration and even gan-

by other forms of infectious arteritis, as for example mycotic embolic arteritis associated with subacute bacterial endocarditis and other forms of septicemia. Such aneurysms are often referred to as mycotic aneurysms. It is generally believed that the primary lesion develops in the vasa vasorum, resulting in local destruction and weakening of the arterial wall. Rarely, certain forms of necrotizing arteritis, such as periarteritis nodosa, may also lead to aneurysmal formation. Traumatic aneurysms are produced by direct or indirect injury to the arterial wall, often resulting in hemorrhagic extravasation. The extent of the hematoma which then develops is limited by the periarterial tissues, and the arterial wound remains open, producing the so-called "pulsating hematoma." This extravascular space becomes lined with endothelium.

*Clinical Manifestations of Aneurysms of the Peripheral Arteries.* As indicated in the foregoing section, the commonest cause of aneurysms of the peripheral arteries is arteriosclerosis. Accordingly, they are encountered most frequently in elderly patients. They are much more prevalent in the lower than in the upper extremities, being commonest in the popliteal and femoral arteries. The arteries most frequently involved in the upper extremities are the subclavian, axillary and brachial.

Often the only manifestation of these aneurysms is the presence of a mass, although large ones may cause pain by pressure on surrounding structures. Large popliteal aneurysms, for example, may produce weakness and even paresis of the peroneal group of muscles and manifestations of venous obstruction caused by pressure on the popliteal vein. Rapid enlargement of an aneurysm is commonly associated with pain, especially if rupture with leakage of blood occurs. Arteriosclerotic aneurysms of the lower extremities are usually associated with symptoms of occlusive arterial disease. In fact, the symptoms may be exaggerated by the aneurysm. The increase in diameter of the vessel produced by the aneurysm results in reduction in the effective blood pressure distal to the aneurysm. In some instances, thrombosis develops and may produce sudden occlusion of the artery.

*Diagnosis.* The diagnosis of aneurysm of a peripheral vessel is usually readily made on the basis of a pulsating mass occurring along the course of an artery, with demonstrable expansile pulsations and usually a systolic murmur. In arteriosclerotic aneurysms, calcification can generally be detected roentgenographically; often the mass is outlined with an irregular line of calcium. An arterial aneurysm may be distinguished from an arteriovenous fistula by absence of the characteristic continuous murmur of the latter and lack of venous distention. If the diagnosis is still doubtful, it may be established by demonstration of increased oxygen content of the venous blood in the region of the fistula. In rare instances, malignant neoplasms which are extremely vascular will pulsate, but the degree of pulsation is never as pronounced as that produced by arterial aneurysms. Finally, arteriography may be employed to demonstrate the aneurysm.

*Treatment.* Treatment of aneurysms of the peripheral arteries is primarily surgical and consists of excision of the aneurysm and restoration of normal blood flow. Although the principles of excision are essentially the same in all cases, the manner by which normal circulation is restored varies according to the extent of the lesion. Small aneurysms involving a relatively short segment of artery are excised and blood flow is restored by end-to-end anastomosis of the uninvolved proximal and distal segments. The arterial defect remaining after excision of aneurysms involving longer arterial segments is bridged with a suitable arterial replacement inserted by end-to-end suture (Fig. 265). Some patients with common femoral artery aneurysms may have an extensive segmental occlusion of the superficial femoral artery distal to the aneurysm. After such an aneurysm has been excised, normal blood flow is restored distally through a bypass graft, one end of which

siding in three to eight weeks. Treatment is nonspecific, although corticotropin and cortisone may be helpful in the management. Rest, local hot applications and salicylates may ameliorate the symptoms.

### *Erythema Induratum*

Erythema induratum is a chronic form of nodular vasculitis which was formerly believed to be of tuberculous origin, but a nontuberculous type is now recognized. The lesions, which occur as nodules in the skin and subcutaneous tissue, are characterized pathologically by proliferation of endothelial and fibroblastic cells with collections of lymphocytes and plasma cells, and endothelial proliferation of the small vessels. Clinical manifestations consist in the occurrence of painful, tender, red to purplish nodules in the skin and subcutaneous tissue of the legs, usually posteriorly. The lesions tend to be chronic, undergoing necrosis and ulceration and sometimes persisting for years. As the lesions heal they leave a depressed pigmented area.

Treatment is generally unsatisfactory, consisting essentially in bed rest, elevation of the extremities, moist compresses and elastic bandages. Antibiotics and adrenal cortical therapy have been employed with equivocal results.

### *Nonspecific Arteritis*

Still other rare forms of nonspecific obliterating arteritis have been encountered but the exact nature of this type of lesion is not clear. In some instances these vascular disturbances resemble other circulatory disorders associated with vasoconstriction, but the pathologic changes observed in the involved vessels do not conform to any of the well established patterns of vascular diseases.

## ANEURYSM[94-99]

The term "aneurysm" is derived from the Greek word meaning "to widen or dilate" and is applied to any abnormal dilatation of an artery resulting from weakness of the arterial wall due to injury or disease. Aneurysms may be classified in several ways according to their causation or their anatomic structure. Uniform dilatation of a segment of an artery is known as a fusiform aneurysm. An outpouching from one portion of the wall of an artery is referred to as a saccular or sacciform aneurysm. When the aneurysmal sac consists of periarterial tissue or blood clot, it is referred to as a false aneurysm. Formation of an intramural channel, resulting from splitting of the inner layers of an artery for varying distances and communicating with the lumen of the artery both at the original opening and at a distal point, is known as a dissecting aneurysm.

According to their etiology, aneurysms may be classified as (1) congenital, (2) arteriosclerotic, (3) syphilitic, (4) traumatic or (5) embolic. Congenital aneurysms are relatively rare, and although they may occur in any portion of the arterial bed, one of the most frequent areas of involvement is the anterior portion of the circle of Willis and its branches. They may be multiple. Arteriosclerosis is by far the most frequent cause of aneurysm, especially in the peripheral vessels. They result most often from atheromatous degeneration and localized destruction of the internal and middle coats, which gradually give way to the expansile force of the blood current. Arteriosclerotic aneurysms occur most frequently in a segment of artery which is not surrounded by skeletal muscles and is therefore subject to the constant trauma of bending or flexion during physical activity, such as the terminal portion of the abdominal aorta and the femoral, popliteal and axillary areas. They occur much more frequently in men than in women, and are most commonly encountered in patients past the age of 60 years. Syphilitic aneurysms are believed to be due to intimal proliferation and consequent obstruction of the vasa vasorum, causing impairment of the medial coat and degenerative changes in this layer and, in turn, localized weakening of the wall and its gradual dilatation. Syphilitic aneurysms occur predominantly in the thoracic aorta and only seldom involve the peripheral vessels. Aneurysms may also be produced

*Physiology.* The altered physiology which results from an abnormal communication between an artery and a vein has been intensively studied. William Hunter was probably the first to recognize this lesion as consisting of a communication between artery and vein. In 1875 Nicoladoni first demonstrated the fact that compression of the artery proximal to the fistula results in lowering of the pulse rate. Fifteen years later Branham again called attention to this phenomenon, which is now known as Branham's sign. Subsequently, many observers singly called attention to the various physiologic alterations resulting from arteriovenous fistulas, but it remained for Holman to clarify these changes. In 1930 he published the results of his extensive experimental observations, which may be briefly summarized here:

A. Immediate changes following establishment of a fistula: (1) fall in arterial blood pressure, (2) increased heart rate, (3) increased venous pressure, proximal and distal to the fistula, (4) increased cardiac output, and (5) temporary decrease in size of the heart and of the artery proximal to the fistula.

B. Later effects of an arteriovenous fistula: (1) permanent diversion of a part of the circulating blood from the normal capillary bed into the fistulous circuit, (2) gradual increase in total blood volume, (3) dilatation of the heart and of the artery and vein proximal to the fistula, (4) development of extensive collateral circulation owing to lowered resistance in the region of the fistula, (5) slight hypertrophy of the heart, and (6) increased pulse pressure due to elevation of systolic pressure and diminution of diastolic pressure. All these changes are dependent upon the distance of the fistula from the heart and the size of the abnormal communication.

C. Immediate changes following closure of the fistula: (1) rise in the arterial blood pressure, involving both systolic and diastolic levels, (2) immediate slowing of the pulse, (3) decreased venous pressure proximal to the fistula, (4) decreased cardiac output, and (5) temporary increase in size of the heart, due to overdistention.

D. Later effects of closure of the fistula: (1) gradual adjustment of blood pressure to normal level, (2) gradual decrease in total blood volume, (3) gradual recovery of pulse rate to normal, and (4) decrease in size of heart and of artery and vein proximal to fistula.

*Clinical Manifestations.* Acquired arteriovenous fistulas are manifested clinically by elevation in temperature of the extremity below the fistula, increase in size of the superficial veins of the part, increase in size of the extremity if the fistula develops prior to closure of the epiphysis, and frequently discovery by the patient of a murmur and thrill in the region of the fistula. If the fistulous opening is large and a major vessel is involved, other more severe changes may occur. Extreme increase in venous pressure, which results from the fistula, may produce chronic ulceration and eczema of the extremity. Symptoms of cardiac failure may appear late.

In an acquired arteriovenous fistula, examination will usually reveal the healed scar of the injury, and a continuous thrill and murmur can be detected at the site of the fistula. Except in small distal fistulas, compression of the fistula or of the artery proximal to it will almost always produce a significant decrease in pulse rate. Additional studies may be necessary to confirm the diagnosis. Samples of blood drawn from the vein of the affected extremity and the opposite extremity will show considerable increase in arterial oxygen concentration in the blood from the involved region. Arteriography with contrast media may also be used to demonstrate the lesion.

In general, the symptoms and signs of congenital arteriovenous fistulas are similar to those of acquired fistulas. Certain differences, however, are noted. Many of these patients have birthmarks on their extremities. Increased growth of hair and profuse sweating in the involved areas are usually present. Since most of these lesions appear before the epiphysis closes, there is often a striking increase in growth of the involved limb. The temperature of the skin of the affected extremity is higher than that of

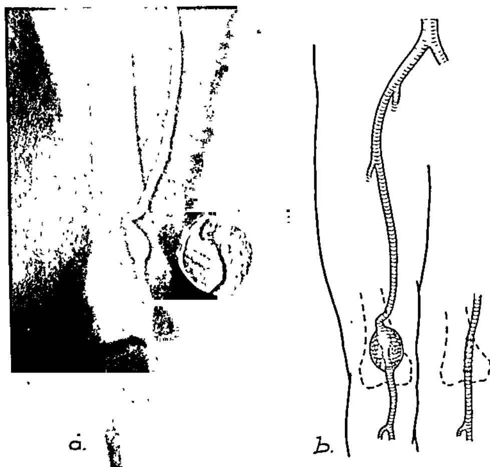



*Figure 265.* *a.* Aortogram showing aneurysm of right popliteal artery, the peripheral outline of which is indicated by peripheral rim of calcium in wall of aneurysm. Superimposed photograph of excised aneurysm in this case reveals the characteristic pathology of dilated lumen of artery partially filled with laminated clot. *b.* Drawing illustrating location of popliteal aneurysm and its treatment by resection and replacement with arterial graft.

is sutured to the proximal severed end of the common femoral artery and the other end to the side of the patent popliteal artery distal to the occlusive process. Circulation is restored in the thigh by suturing the distal end of the patent profunda femoris artery to the side of the graft. In sacciform aneurysms, with involvement of only a portion of the wall, the sac may be completely excised and the opening repaired by lateral arteriorrhaphy.

### ARTERIOVENOUS FISTULA[84, 99]

An arteriovenous fistula is an abnormal communication between an artery and a vein. Two general types are recognized: (1) the traumatic or acquired and (2) the congenital. The former is almost invariably the result of a penetrating injury, such as a stab or gunshot wound. These fistulas are usually single, but injuries from shotgun wounds may produce multiple fistulas. There are several forms of acquired or traumatic arteriovenous fistulas, the simplest of which is a direct connection between artery and vein. In other instances an aneurysmal sac is interposed between the artery and the vein. Still other combinations of fistulas and aneurysms are occasionally encountered. These fistulas may be located at any point on the extremity, even the digital vessels.

Congenital arteriovenous fistulas, which are usually encountered in children, result from failure of differentiation of the common embryologic structure into an artery or a vein. In the early process of differentiation, there are multiple communications between arteries and veins. Persistence of these communications results in congenital arteriovenous fistulas. Although they most commonly occur in the extremities, they may also be found elsewhere.

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ARTERIAL THROMBOSIS AND EMBOLISM

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the opposite one. Neither the thrill, or murmur, nor the slowing of the pulse rate on compression of the fistula is as pronounced in the congenital type. Venous distention may be prominent, and in some instances trophic disturbances of the skin with ulceration and eczema may be found. There is an increase in the oxygen saturation of the blood in the involved extremity.

***Treatment.*** Treatment of arteriovenous fistulas should be directed toward elimination of the fistula and re-establishment of a normal vascular channel. If the fistula is small, simple division of the fistula with repair of the defect in the artery and vein is all that is necessary. If the sac of the aneurysm is associated with the fistula, this too can be excised and the artery repaired. In some instances excision of a segment of the artery and end-to-end anastomosis can be accomplished without difficulty. If the segment of artery that is removed is too large to permit end-to-end anastomosis, a graft can be used to repair the defect. The rationale for restoring arterial continuity is based on the fact that, although collateral circulation may be adequate to maintain viability of the extremity following ligation and excision, in many instances arterial blood flow is not adequate during activity and exercise.

The treatment of congenital arteriovenous fistulas is much more difficult and often unsatisfactory, because the communications are usually widespread and extensive. Under these circumstances, surgical closure or obliteration of the fistulas may be impossible and conservative measures consisting of use of elastic compression bandages must be employed. Operative intervention may be employed in certain instances where the lesion is fairly well localized or superficial, or where it may be possible to diminish the extent of the process by multiple stage operations.

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are the external pudendal vein, the superficial lateral circumflex iliac vein, the superficial epigastric vein and the lateral and medial femoral cutaneous veins. There are a number of communicating veins between the superficial and deep veins. The superficial veins and the venae comites have numerous valves directing the flow of blood upward. The communicating veins have valves directing the flow of blood from the superficial toward the deep system (Fig. 270). There are varying numbers of valves in the popliteal, femoral and iliac veins. Competent valves are usually present at these levels but it is not unusual to find no valves in these veins, or relative or complete incompetence of the few valves which are present.[1, 2]

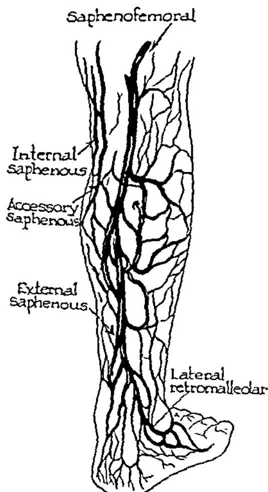



*Figure 267.* External saphenous system which begins on the lateral aspect of the foot and courses up the posterior aspect of the leg to empty into the popliteal vein at the popliteal space. Joining the external saphenous vein in its upper extremity is the saphenofemoral vein, which drains the lower part of the posterior aspect of the thigh. There are rich communications between the internal and external saphenous systems on the medial side of the leg.

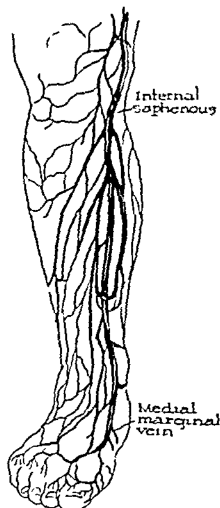



*Figure 268.* The inferior portion of the internal saphenous vein which begins on the anteromedial aspect of the foot and extends up the anteromedial aspect of the leg passing on the posteromedial aspect of the knee.

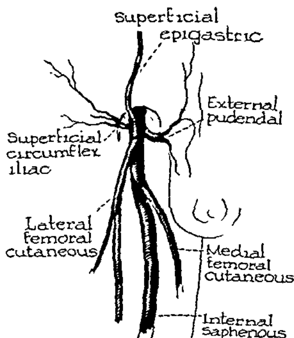



*Figure 269.* The upper end of the internal saphenous vein at its point of entrance into the fossa ovalis. A large number of rather constant tributaries empty into the upper end of the internal saphenous vein.

*Chapter 19*

# Diseases of Veins and Lymphatics

*By Paul T. DeCamp*

Disabling disorders of the venous and lymphatic systems requiring treatment frequently occur in the ambulatory patient. The predilection for the lower extremity is probably due primarily to man's erect posture and the resultant high venous, lymphatic and tissue pressures in that location.

## ANATOMY

There are two systems of veins in the lower extremity. The superficial system in the subcutaneous tissues consists primarily of the internal and external saphenous veins and their tributaries. The deep system consists of paired vena comites accompanying each artery in the foot and leg. In the popliteal region these unite to form the popliteal vein which extends upward in the thigh as the superficial femoral vein. In the upper part of the thigh this vessel unites with the deep femoral vein to form the common femoral vein, which passes upward into the external iliac vein. (Fig. 266).

The subcutaneous veins of the lateral aspect of the foot and heel unite as the lateral retromalleolar vein, which curves around and behind the lateral malleolus. This vein continues up the posterior aspect of the leg as the external saphenous vein, which receives tributaries from the posterior aspect of the leg and, piercing the deep fascia of the popliteal space, enters the popliteal vein (Fig. 267). A communication between the external and internal saphenous veins around the medial aspect of the knee is known as the accessory saphenous vein. A prominent vein may extend upward from the external saphenous vein in the posterior aspect of the thigh as the saphenofemoral vein (Fig. 267). The lateral retromalleolar vein has direct communications with the deep veins of the lower leg so that it is a convenient site for injection of radiopaque substances into the deep venous system.

The medial end of the dorsal venous arch of the foot extends upwards anterior to the medial malleolus as the internal saphenous vein (Fig. 268). It extends up the medial aspect of the leg just posterior to the tibia and, passing around the posteromedial aspect of the knee, continues upwards and slighty laterally to the femoral triangle where it perforates the cribriform fascia to enter the common femoral vein (Fig. 269). Its branches in the vicinity of the fossa ovalis

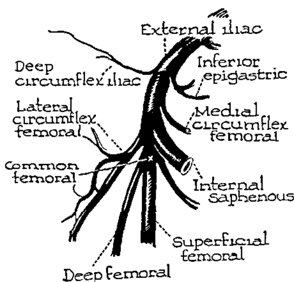



*Figure 266* Deep and superficial venous system at the fossa ovale, common femoral is formed by junction of the deep and superficial femoral veins, all three of these being deep vessels Joining the common femoral at approximately this level is the internal saphenous. All the other vessels are deep ones

venous pressure in the arm at heart level. Pressure in the tissues is slightly lower.[7] In the recumbent lower extremity these pressures are slightly higher than they are in the arm. It is often not appreciated that in the resting *erect* position the venous pressure in the lower leg is about 130 cm. of water, or more than ten times greater than that in the recumbent position. On standing quietly a person unconsciously moves his legs and fidgets about enough to cause a drop in the venous pressure well below that when he is erect and completely inactive.[8] Pressures of similar magnitude exist in the capillaries and, to prevent prompt massive transudation of fluid out of the vascular system on standing, a correspondingly high pressure develops promptly in the extravascular tissues of the leg. The pressure must act as a disruptive force and seriously interferes with the healing of cutaneous lesions. This force may be completely obviated by placing the patient in the recumbent position. A wound in the leg will then heal as rapidly as one elsewhere in the body. If the patient must be ambulatory, elastic compression of the leg partially counteracts the deleterious effects of these high vascular and tissue pressures.

Pressures in the veins and tissues of the *resting* lower extremity, whether recumbent or erect, are not influenced by the presence or absence of competent venous valves.[9, 10] However, walking causes muscular contractions within the deep fascial sheath to pump blood out of the deep veins and the pressure in them falls, particularly if the valves are competent.[11, 12] Blood flows in rapidly from the subcutaneous veins. If the valves of the deep system are incompetent, the fall in venous pressure with ambulation is more limited. If valves are incompetent in the communicating and superficial veins, blood may flow sluggishly on ambulation but it rarely flows retrograde unless the patient suddenly coughs or strains.[13] Competence of valves affects

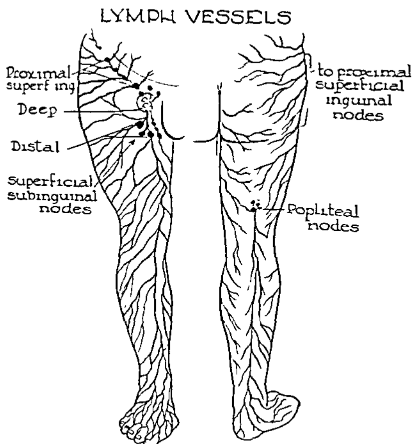



*Figure 271.* Lymph vessels and lymph nodes of the lower extremity. Lymph vessels on the posterior aspect of the leg drain into the popliteal nodes. Those on the anterior aspect of the leg and thigh drain into the subinguinal nodes, both the superficial and the deep.

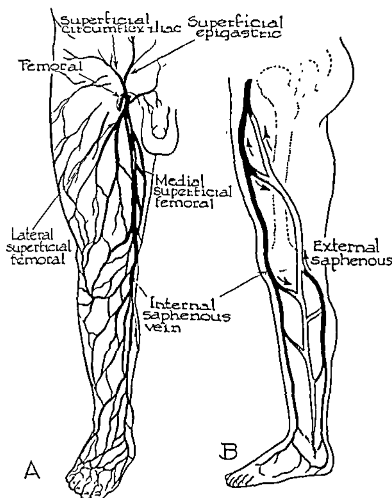



*Figure 270. A,* Entire internal saphenous system extending from the anteromedial aspect of the foot up to the fossa ovalis *B,* Arrows indicating the direction of flow in the superficial, communicating, and deep venous systems The direction of flow normally in both the superficial and deep veins is upward and in the communicating veins from the superficial to the deep.

Subcutaneous lymph vessels from the lateral aspect of the foot, heel and posterior aspect of the leg enter lymphatic vessels accompanying the external saphenous vein and end in superficial or deep popliteal lymph nodes in the popliteal space. The remaining subcutaneous lymphatics of the lower extremity communicate with lymph vessels accompanying the internal saphenous vein and terminate in lymph nodes in the subinguinal area (Fig. 271). The deep lymph vessels accompany the deep blood vessels. Many of the vessels from the foot and leg pass into the popliteal nodes, and others pass directly to the deep subinguinal nodes. The deep vessels of the thigh empty into the deep subinguinal nodes and the hypogastric nodes. There are important concentrations of lymphatic vessels about the popliteal vein and particularly about the external iliac vein, which is surrounded by lymph vessels draining all the superficial and deep structures of the lower extremity.[3,4]

Numerous lymphatic channels communicate directly between cutaneous and subcutaneous lymphatics and the deep subfascial lymphatics. Subcutaneous lymph normally passes directly into the deep vessels rather than along the longitudinal subcutaneous vessels.[5]

## PHYSIOLOGY

There is no convincing evidence that in disorders of the venous system the arterial blood supply to the lower leg is regularly deficient. The venous and lymphatic circulations of the lower extremities are similar to those in the soft parts elsewhere, with one important exception. Normal venous pressure is between 5 and 10 cm. of water,[6] but this figure refers to the resting recumbent

Excessive sweating suggests sympathetic overactivity. The temperature of the extremity reflects the adequacy of the arterial circulation. Percussion of a vein with retrograde transmission of the impulse for some distance suggests valvular incompetence.

### CLINICAL DIAGNOSTIC TESTS

In the presence of subcutaneous varicosities several clinical tests are useful in determining the patency of the deep veins and in evaluating valvular competence in the deep, communicating and superficial veins. Trendelenburg's test[12] consists first in elevation of the leg from recumbency with emptying of all varices. The patient is then permitted to stand; prompt filling of the varices indicates valvular incompetence in the superficial or deep veins. The test is repeated with digital or tourniquet obliteration of the internal saphenous vein at the groin (Fig. 272). If the veins below the tourniquet require 30 to 40 seconds to fill, the valves in the deep and communicating veins at that level are competent. If the veins below the tourniquet fill within a few seconds, the valves in the deep veins at that level may be incompetent and the valves in the communicating veins below that level are certainly incompetent (Fig. 273). If valvular incompetency is present in the communicating system in the upper thigh, the test may be repeated with the tourniquet at lower levels (Fig. 274). The result of the Trendelenburg test is considered positive if the veins in the leg promptly fill on standing. The result is considered doubly positive if reflux filling occurs in spite of a tourniquet high in the thigh. It is important that all tourniquets be applied tightly or the superficial veins will not be completely occluded. One need not fear occluding the deep veins, as that requires an extremely tight constriction.

Perthes' test is designed to determine

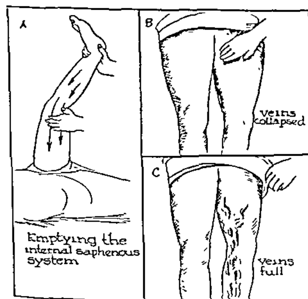



*Figure 272.* Trendelenburg test *A*, The extremity is elevated and the blood in the internal saphenous vein is milked out of it by passing the hand from the origin of the internal malleolus down towards the groin. *B*, The upper end of the internal saphenous vein is compressed by means of the hand, and the patient stands. *C*, The compression is removed and one observes whether there is retrograde filling of the veins of the internal saphenous vein from above downward.

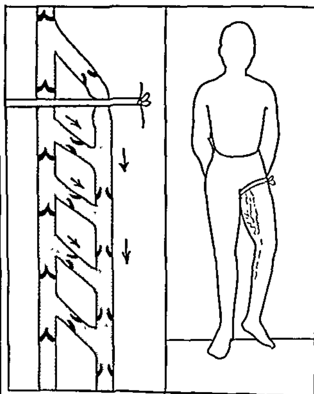


*Figure 273.* Compression of the upper end of the internal saphenous vein is maintained by a tourniquet which prevents regurgitation from the femoral into the internal saphenous vein at the fossa ovalis If the valves of the communicating veins in the thigh are incompetent, there is rapid filling of the varicosities below the tourniquet, because of regurgitation from the deep to the superficial circulation. Immediate refilling of varices suggests incompetence of the valves in the deep veins, permitting blood to drop back from the veins of the trunk.

venous and other pressures in the leg only during exercise in the erect position. On the other hand, venous obstruction may affect pressures in the recumbent, resting, erect and ambulatory states, but unless the obstruction is severe, only the ambulatory venous pressure is elevated.[14, 15]

Obesity or any intrapelvic or intra-abdominal mass tends to increase the venous pressure in the lower extremity by pressure on the lower abdominal and pelvic veins. The negative intrathoracic pressure assists in the return flow of blood to the heart, but this is a relatively minor factor in the erect position. Muscular activity assists the flow of lymph in an extremity by intermittent compression of the valved vessels.

It is a common observation that edema of the lower legs and feet is prone to occur in warm weather. Chronic ulcers of the leg commonly occur in the tropics apparently spontaneously. It is of interest that at higher temperatures physiologic changes increase formation of edema, and possibly secondary changes such as ulcers. Cutaneous vasodilatation increases the cutaneous blood flow. Experimentally, with a fixed venous pressure capillary transudation increases with higher temperatures.[16] Furthermore, at warmer temperatures the rate of blood flow is increased, venous filling is more rapid and the ambulatory venous pressure levels are higher.[8] Because of slow venous refilling, arterial insufficiency causes a low ambulatory venous pressure.[17]

#### CLINICAL HISTORY

Chronic conditions of the lower leg due to disease of the veins or lymphatics and similar conditions due to other causes frequently have a long and complex development. In the interest of correct management of the individual case, as well as better understanding of these conditions in general, an accurate history should be recorded.

The patient may have evidence of phlebitis, lymphedema, pigmentation, dermatitis, cellulitis, fibrosis, varicose veins and ulceration. Only by careful evaluation of the history can the sequence of appearance of the several complications, and their relative importance, be assessed. Edema may have appeared after a frank attack of thrombophlebitis or an injury, with infection, or apparently spontaneously. The significance of varicose veins is entirely different whether they occurred as a primary phenomenon or developed after thrombophlebitis. The term "varicose ulcer" has been erroneously used to include almost all nonspecific chronic ulcers of the lower leg. Actually, a minority occur in association with primary varicose veins. A larger number develop after thrombophlebitis.[18-21]

Symptoms from venous or lymphatic disorders of the lower extremity are usually maximal on prolonged standing and are less severe with ambulation. Increasing discomfort on walking, in the absence of arterial insufficiency, suggests severe venous obstruction and warns against radical obliteration of remaining patent veins.

#### PHYSICAL FINDINGS

The legs should be examined for the presence, severity and distribution of edema. The edema of deep thrombophlebitis surrounds the extremity and extends from below upward. Superficial acute thrombophlebitis is accompanied by edema, redness and tenderness in the region of the involved segment; the edema is seldom generalized. The edema of cellulitis is also localized. Pallor, most noticeable on elevation, indicates arterial insufficiency. Cyanosis on dependency suggests vasospasm. The size, configuration, and distribution of varicose veins are usually apparent on inspection, except in massive edema, when their presence may be masked. Severe edema and distended, tense, superficial veins suggest severe deep venous obstruction.

By palpation the degree of induration of edematous tissues may be ascertained. Brawny induration indicates recurrent infection in the edematous tissues. Invisible varices may be discovered and traced by palpation. In regions of subcutaneous fibrosis veins are felt as soft channels.

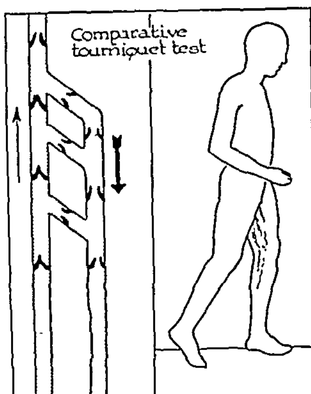



*Figure 276.* Comparative tourniquet test. The patient is instructed to walk, and the examiner observes the effect of muscular exercise on the varicosities. If the valves in the superficial veins and communicating veins are incompetent, the varicosities do not disappear.

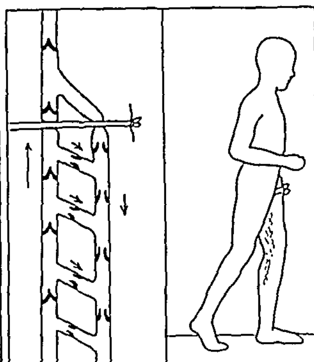


*Figure 278.* Comparative tourniquet test. Tourniquet is placed high on the thigh. If the varicosities below this level do not disappear with walking, the valves of the communicating veins below this level are incompetent.

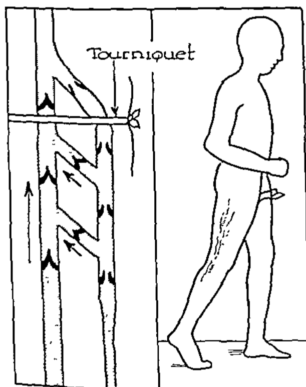



*Figure 277.* Comparative tourniquet test A tightened tourniquet is placed around the upper part of the thigh tightly enough to compress the internal saphenous vein at that level. If all the varicosities below that level completely disappear, the valves of the communicating veins below that level are competent

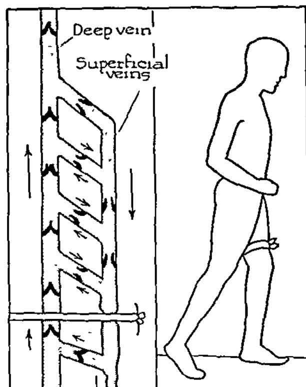



*Figure 279.* Comparative tourniquet test The test is repeated, the tourniquet being applied at various levels on the thigh and leg. If, when the patient walks, the varicosities below the tourniquet completely disappear, the valves of the communicating veins below that level are competent

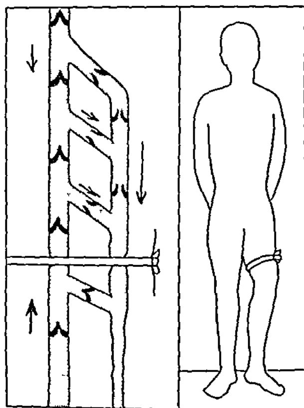


*Figure 274.* Further elaboration of the Trendelenburg test, with the tourniquet placed at the lower part of the thigh and sufficiently tightened to compress the superficial veins If filling of the varicosities below this level does not occur within 30 to 40 seconds, the valves of the communicating veins below this level can be considered competent.

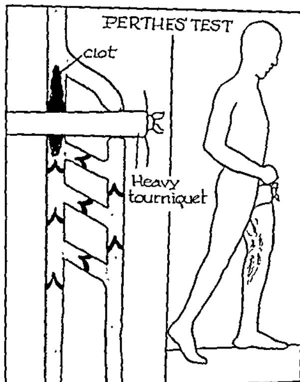



*Figure 275.* Perthes' test. A tourniquet is placed around the upper part of the thigh, and the patient is instructed to walk. If the veins disappear after the patient walks, it is an indication that the deep venous system is patent and that the valves in the communicating veins are also competent If, however, a severe pain develops after the patient walks, it indicates blockage of the deep venous system, as illustrated in this figure.

the patency of the deep venous system.[25, 26] It is performed by binding a heavy rubber band tightly about the upper portion of the thigh and requesting the patient to walk about vigorously. Theoretically, if the deep veins are thrombosed and the superficial veins are completely obstructed by the tourniquet, the leg will swell and become uncomfortable with the increased blood inflow and congestion incident to vigorous exercise. If no discomfort occurs, it may be inferred that serious deep venous obstruction does not occur at that level. It must be emphasized that a tight heavy rubber tourniquet is required to obliterate the superficial veins (Fig. 275). If the test is performed by wrapping elastic bandage around the leg, it is meaningless as the superficial veins are merely supported, rather than occluded, by the bandage.

The comparative tourniquet test of Mahorner and Ochsner[27] is essentially multiple Perthes' tests. It is designed to demonstrate the presence of either deep venous obstruction or deep and communicating valvular insufficiency. The patient is instructed to walk about and the degree of emptying of varicosities is noted (Fig. 276). The exercise is repeated after a tight tourniquet is placed about the upper part of the thigh. If the varices below the tourniquet empty completely, it is considered 4 plus improvement and indicates that the deep veins at that level are open and the valves in the communicating veins are competent (Fig. 277). If the veins fail to empty when he walks with the tourniquet, it indicates either deep venous obstruction or valvular incompetence of the communicating veins (Fig. 278). The test is repeated if necessary with the tourniquet above and below the knee (Fig. 279). Slight improvement through emptying of varices is graded 1 plus, and interme-




*Figure 282.* Phlebograms showing blockage in the region of the popliteal veins. As shown in *A*, the dye passed down the femoral until obstruction was encountered in the popliteal, as illustrated in *B*. *A* is a roentgenogram of the thigh and *B* is a roentgenogram of the leg. (After DeCamp, Schramel, Ray, Feibleman, Ward and Ochsner: Surgery, *29*:44–70, 1951.)

the venous flow and permit a film to be made more leisurely with higher concentration of dye in the veins.

To determine the competency of the valves of the deep veins, retrograde phlebography may be performed.[29] The patient is placed on the table with the head elevated at least 45 degrees. With some experience the femoral vein may be entered through the intact skin, preferably with a curved, short-beveled, No. 20 needle, or it may be exposed by operative dissection. The vein is immediately medial to the pulsating femoral artery in the groin and the needle may be inserted at that point. Twenty to 30 cc. of 35 or 50 per cent solution of Diodrast may be injected slowly and pictures of the thigh and leg are taken at the conclusion of the injection. Gravity will carry the dye down the vein to the first competent valve (Fig. 281). If the valves are incompetent, the dye will descend all the way to the lower leg (Fig. 282). A point of blockage by a thrombus can also be visualized (Fig. 282).

A careful history to elicit whether walking is comfortable and evaluation of a properly performed comparative tourniquet test will give considerable, and usually adequate, information con-

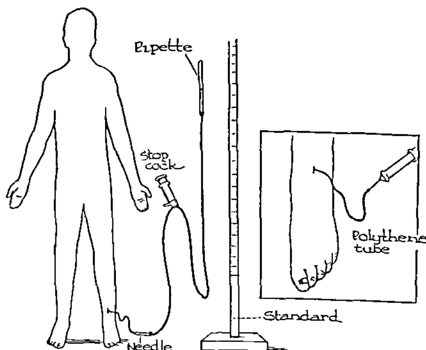



*Figure 283.* Method of obtaining ambulatory venous pressure. A polyethylene tube is inserted into a vein of the ankle or foot, which is connected through flexible rubber tubing and three-way stopcock attached to a reservoir syringe to a length of small-bore glass tubing, which is used to measure the venous pressure. (After DeCamp, Schramel, Ray, Feibleman, Ward and Ochsner: Surgery, *29* 44-70, 1951.)

diate grades are 2 and 3 plus. The venous valves below the level at which all varices disappear can be assumed to be competent. The comparative tourniquet test, therefore, demonstrates whether the valves in the superficial and communicating veins are competent or not and the level of incompetency if such exists. It is likely that this test is influenced by the competence or lack of competence of valves in the deep veins as well.

### SPECIAL DIAGNOSTIC TESTS

In the majority of cases sufficient information for diagnosis may be obtained by the foregoing examination and tests. In some instances further desirable information may be secured by performance of phlebography, or determination of the ambulatory venous pressure pattern. A "peripheral" phlebogram[28] may be obtained by injecting 30 cc. of 35 per cent solution of Diodrast into a peripheral vein over a period of about 40 seconds. At the conclusion of the injection a picture of the leg is taken and as rapidly as possible one of the thigh. The leg should be internally rotated for the best exposure (Fig. 280) In our experience the lateral retromalleolar vein is a satisfactory site of injection because, although it is the distal extension of the external saphenous vein, the deep vein communications are so direct and effective that filling of the deep system may be obtained without use of a proximal tourniquet. This examination reveals obliteration or irregularities in the veins. The chief difficulty lies in the fact that if a segment of a vein does not appear on the film, one is not sure whether the lumen of the vein is obliterated or whether the contrast substance has merely failed to reach that vein. If the contrast medium passes out of the leg too rapidly, the patient's head may be elevated to retard



*Figure 281.* Phlebogram obtained after injection of contrast substances into the femoral vein The dye has been carried by the blood down to the first competent valve, which is seen at the junction of the lower and middle thirds of the leg. (After DeCamp, Schramel, Ray, Feibleman, Ward and Ochsner: Surgery, 29.44–70, 1951)

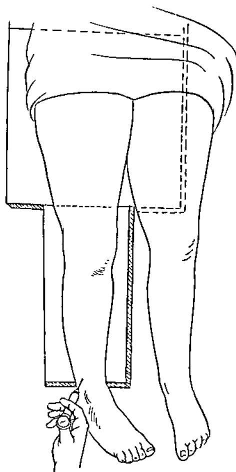


*Figure 280* Position of the leg and point of injection during phlebography

attached to a reservoir syringe, to a length of small-bore glass tubing (Fig. 283). A measured standard is used to measure the height of the venous pressure. The system is filled with pyrogen-free physiologic saline solution containing heparin or sodium citrate to prevent coagulation. Normally, on ambulation in a nonprogressive step (60 double steps per minute, the feet being raised 6 inches), the pressure will fall rapidly from the resting level (approximating heart level) to a point 50 to 90 per cent lower and will maintain this low level until ambulation ceases. When exercise ceases, the pressure level will rise over a 30 to 45 second interval to the previous resting level (Fig. 284).

In the presence of venous obstruction or valvular incompetence the pressure on ambulation falls more slowly and to a lesser degree, but rises more rapidly on cessation of exercise (Fig. 285). The test may be repeated with a tourniquet occluding the superficial veins. If the pressure is then higher, caution must be exercised in removing superficial veins. In our opinion, the saphenous vein in the thigh should be preserved if at all possible. With high grade venous obstruction the ambulatory venous pressure will rise during ambulation and will go above the resting level after conclusion of the exercise.

## DISEASES OF VEINS

### Varicose Veins

Varicose veins are veins that are enlarged and frequently tortuous, with diseased walls whose valves are usually incompetent. A distinction is not generally made between *primary* varicose veins, which appear spontaneously, and *secondary* varicose veins, which are postphlebitic phenomena. Primary varicose veins are sometimes hereditary and develop gradually. They are usually large and tortuous and are commonly more prominent in the thigh. They rarely give rise to serious complications, usually after many years. Secondary varicose veins are rarely large or tortuous. They are usually more prominent in the leg and are often associated with severe intractable lymphedema, pigmentation, recurrent cellulitis and ulceration.

Primary varicose veins frequently occur in persons with a familial history of similar disorders. An inherent weakness of the venous system of the lower extremity is undoubtedly present in most instances. Any occupation that entails standing for long periods of time is prone to precipitate the appearance of varices. Prominent veins often first appear during pregnancy, increase in size in the later months and frequently regress after parturition. Obesity or pelvic tumors, which undoubtedly operate through compression of the pelvic veins, may precipitate or aggravate varices.

Primary varicose veins usually occur as tortuous enlargements of the secondary branches of the internal or long saphenous venous system in the leg and on the anteromedial aspect of the thigh (Figs. 268, 269, 286). The external, or short, saphenous venous system on the posterior aspect of the leg is involved less frequently (Fig. 267). In some instances both systems are involved. The saphenofemoral vein may be involved as it descends in the posterior aspect of the thigh to empty into the external saphenous vein at the knee (Fig. 267). Veins over the lower buttocks and upper thigh posteriorly may become varicose. These latter varices rarely give rise to complications, but they may be unsightly or painful.

In some cases of primary varicose veins,[34, 35] particularly in pregnancy, and in some cases of postphlebitic varicosities,[36] the varices are associated with direct arteriovenous communications.

Small, diffuse intracutaneous varices may occur anywhere on the thigh or leg and are often widespread (Fig. 287). Complications are rare, but they may be uncomfortable and treatment is difficult and tedious. Occasionally, without any history of preceding phlebitis, the internal saphenous vein, though almost straight in its course, will become slightly enlarged and at times tender. On percussion an impulse may be transmitted in either direction for long distances. This may not be considered a varicose

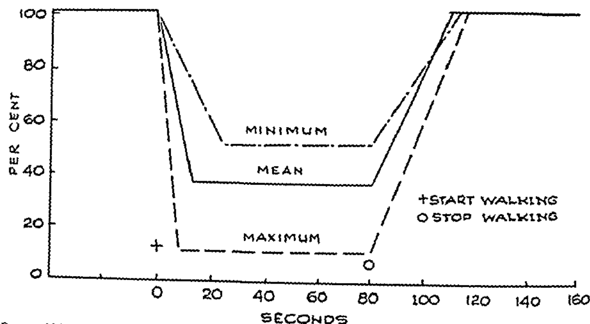



*Figure 284.* Changes in ambulatory venous pressures, associated with walking, in ten normal individuals (After DeCamp, Schramel, Ray, Feibleman, Ward and Ochsner: Surgery, *29*:44–70, 1951.)

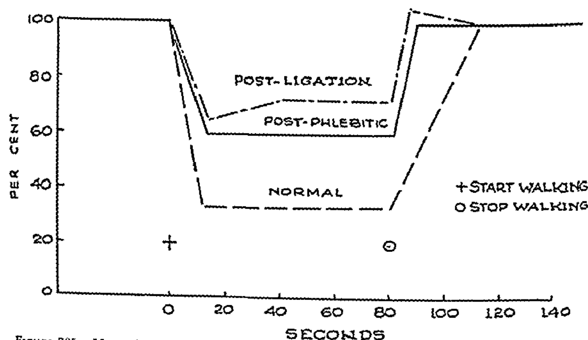



*Figure 285.* Mean changes in ambulatory venous pressures on walking in normal individuals, in those with the postphlebitic syndrome, and in those after ligation of the deep veins. (After DeCamp, Schramel, Ray, Feibleman, Ward and Ochsner: Surgery, *29*:44–70, 1951.)

cerning the degree of venous congestion in a leg. In the presence of secondary subcutaneous varicose veins in the leg and a suggestion of a high degree of venous stasis, valuable additional information may be obtained by measuring the ambulatory venous pressures.[30–33] It will assist in determining the safety and advisability of extensive removal of subcutaneous varicosities. Because of the relatively slow blood flow through an extremity at rest, the degree of venous obstruction must be extreme for the venous pressure to be abnormally elevated in either the resting recumbent or resting erect position. With exercise the venous pressure pattern is sensitive to lesser degrees of venous obstruction. A flexible polyethylene cannula is inserted into an exposed vein of the foot or ankle. This is connected through flexible rubber tubing and a three-way stopcock,

velop in the same area. Occasionally, a superficial varix will rupture either spontaneously or after trauma, and the associated hemorrhage is profuse until the part is elevated or pressure is applied. Ulceration may appear, usually on the anteromedial aspect of the lower leg in association with varices of the internal saphenous system, or on the posterolateral aspect of the lower leg in association with varices of the external saphenous system, which are the areas with greatest venous stasis.

*Diagnosis.* The diagnosis of varicose veins rests upon obvious physical signs in most instances. The veins appear as enlarged, tortuous, usually raised, compressible, cordlike structures in the subcutaneous tissue of the lower extremity. If the tissues of the leg are indurated, the enlarged vein will be felt as a soft channel in the midst of the firm tissues. In cases in which the vein is not tortuous but enlarged and tense, transmission of a percussion pulse wave for long distances in either direction is an important

taneous or primary varicosities and those secondary to deep thrombophlebitis. It is of utmost importance to determine whether episodes of edema have occurred and whether they were preceded or followed by the appearance of varices. Unilateral edema of considerable degree is rarely caused by primary varicose veins and usually indicates thrombophlebitis, lymphedema or some related condition. In secondary varicosities the varices are commonly less tortuous and are generally more pronounced in the leg than in the thigh. Complications are commoner with secondary varicose veins because of the multiple complicating lesions of deep thrombophlebitis.

Thrombophlebitis of a varix is distinguished from regional cellulitis by palpation of the tender, indurated varicose mass in the center of the area of redness, swelling and warmth. In both instances swelling will center about the area of involvement, and in this will differ from the edema of deep thrombophlebitis which involves the entire circumference of the extremity beginning in the feet and extending upward for variable distances, depending on the extent of the phlebitis.

In the presence of concurrent varicosities and orthopedic static deformities, careful evaluation of the relative severity of each condition is required. The response to conservative therapeutic measures for either condition is helpful in the differential diagnosis. Rest in bed, or elastic support, will usually alleviate symptoms secondary to varicose veins. Appropriate arch supports or other orthopedic correctives will improve the symptoms due to static disorders.

The presence and degree of valvular incompetence may be determined by the simple clinical tests previously described. In doubtful cases anatomic (phlebography) and physiologic (ambulatory venous pressure) studies may be necessary.

*Treatment.* Whenever possible a patient with uncomfortable spider varices should be treated by reassurance alone. Supportive therapy with elastic stockings or bandages is rarely tolerated. Surgical correction is too difficult and deforming. If relief is demanded, it may be accomplished by injection of relatively mild sclerosing solutions. As the vessels are often too small to be injected directly, the material must be injected into the area in a punctuate manner. The tissues are anesthetized with 0.5 or 1.0 per cent solution of procaine. A few drops of 5 per cent solution of sodium morrhuate, or other sclerosing solution, is injected by multiple punctures into the area. It is unwise to inject more than 0.6 to 0.8 cc. into a given area at one time. Repeated treatments are required to cover large areas.

Moderate, scattered varices which are not associated with incompetent valves may also be controlled by injection of sclerosing solutions. We inject from 0.5 to 1.0 cc. of sodium morrhuate or sodium tetradecylsulfate solution into each vein. With the patient erect a No. 25 French hypodermic needle attached to a syringe containing the sclerosing agent is introduced into the lumen of the vein. As



Fig 286.

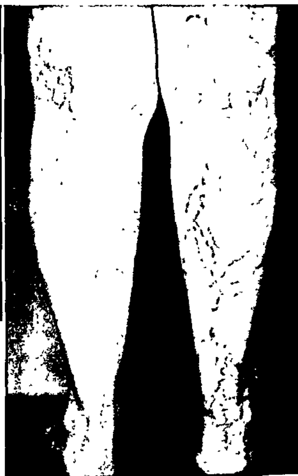


Fig. 287.

*Figure 286.* Varicosities involving the internal saphenous vein of the thigh and leg.

*Figure 287.* Infra-red photograph of superficial varicosities involving branches of the external saphenous system. The varicosities are much more visible than ordinarily because of the infra-red photograph.

vein but it may give rise to severe pain and large, intractable ulcers. This probably represents spontaneous phlebitis in a previously slightly dilated saphenous vein, which explains the development of the relatively serious complication (painful, persistent ulcer) as contrasted with the usual absence of sequelae in the much larger and tortuous primary varices.

Symptoms. Varicose veins are frequently asymptomatic. Pain, when present, seems to bear no relation to the size of the varices. Large ones are often painless; yet a tense young woman may complain bitterly of discomfort associated with small, even spider, varices. The extremity may feel heavy and tense, particularly after standing. Discomfort in the knee joint may be associated with varices of the lower thigh or upper leg. Not infrequently, pain in the lateral aspect of the leg and thigh in a patient with varicose veins is due not to the veins but to orthopedic conditions, such as pes planus. The straight, pipestem varicose vein may be painful and uncomfortable. Thrombophlebitis may develop in a segment of a varicose vein with pain, tenderness, induration, redness and edema limited to the course of the vein. Warmth alone may be felt in a varix, commonly during pregnancy, which suggests a direct arteriovenous communication. This may be confirmed by the observation of elevated oxygen saturation of a specimen of blood from the varix or by appropriate arteriography.

Edema of the foot or leg is rarely associated with primary varices and is moderate to minimal in degree when present. Pigmentation may appear gradually in the lower third of the leg, or it may follow an episode of cellulitis. An eczematoid type of dermatitis may de-

els, also with use of a local anesthetic. It is important that segments be removed below the lowest demonstrable level of valvular incompetence. This operation ("high-low" saphenous vein ligation) may be used in appropriate cases of moderate severity.

Retrograde injection of a sclerosing solution at the time of ligation is hazardous because of possible induction of deep thrombosis, and it is less reliable than extensive surgical excision. Voluminous dressings are placed over the wounds and pressure is applied with simple elastic bandages or elastic adhesive bandages. The patient continues ambulatory, being required to walk about at least once an hour while awake. As mentioned previously, only the milder forms of varicose veins can be treated satisfactorily by injection of sclerosing agents or "high-low" ligation, and recurrence of varicosities is not infrequent. In many cases either will prove inadequate and the more effective operation of high ligation and *stripping* will be necessary. Other radical procedures, such as subfascial ligation of perforating veins, may also be desirable. It is particularly important to remove all veins in the region of ulceration. These operations are hospital procedures. Varices of the external saphenous system are controlled by excision of a segment of the vein at its junction with the popliteal and by stripping or excision of varicose veins of the leg below.

With adequate removal of varices there is no danger of recurrence in the same area but later new varices may appear and require therapy. In primary varicose veins, even when complicated by ulceration, adequate removal of the veins gives an excellent prognosis because the varices constitute the single underlying pathologic change. Treatment of complicating cellulitis or dermatitis is described in the discussion of the postphlebitic syndrome.

### Venous Thrombosis[37]

Venous thrombosis occurs in two relatively distinct forms. On the one hand, phlebothrombosis occurs in a previously undamaged vein, forming a red friable clot which is prone to break off, producing lethal or sublethal emboli. There is no inflammation of the vein and the lymphatics are not involved. The thrombus in phlebothrombosis is due to increased coagulability of the blood resulting from tissue injury and to vascular stasis in the segment of vein involved. Chronic residuals of this condition are uncommon and, when present, are of moderate to minimal severity. On the other hand, venous thrombosis may accompany or follow severe inflammation of the venous wall and the perivenous tissues, including the perivenous lymphatics. In such a case of thrombophlebitis there develops a white thrombus which tends to remain fixed to the vein wall. A propagating red thrombus may form proximally, particularly if the patient is inactive. Embolism may occur, though rarely, from the propagating red thrombus, but the emboli are smaller and rarely lethal. Phlebothrombosis may be completely asymptomatic or may be accompanied by slight swelling of the ankle and discomfort in the calf. Not infrequently, the patient is apprehensive and has a sense of impending disaster. Unexplained tachycardia may be present. Physical examination may reveal minimal edema of the ankle and lower leg, tenderness in the calf, and pain in the calf on dorsiflexion of the foot (Homans' sign[38]). Thrombophlebitis causes extensive edema, often asymptomatic but sometimes associated with pain, coldness and blanching of the extremity. Fever occurs in severe cases. Examination reveals moderate to severe edema of the leg which may extend to the thigh and even to the abdomen. The blanching of the extremity as described in the designation "phlegmasia alba dolens," originally thought to be due to lymph stasis, has been demonstrated by Ochsner and De Bakey[39] to be due to ischemia produced by reflex arteriolar spasm. It should be emphasized that thrombophlebitis may occur with no fever and little pain. If there is considerable edema, the diagnosis of thrombophlebitis may be made, and the danger of serious embolism is slight.

In "phlegmasia cerulea dolens" mas-

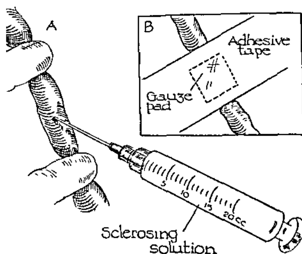



*Figure 288.* *A*, Technique of injection of varicosities An attempt is made to isolate the segment to be injected between the fingers The needle, which is attached to the syringe containing the sclerosing agent, is introduced into the segment of vein *B*, After injection of the sclerosing agent, a pad is placed over the vein and held in place by adhesive plaster.

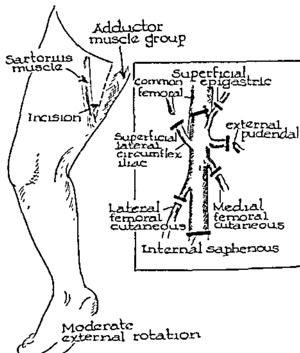



*Figure 289.* Longitudinal incision along the internal saphenous vein which is medial to the pulsation of the femoral arteries, performed with use of a local analgesic Through this incision a relatively long segment of internal saphenous vein and all its immediate tributaries can be removed

soon as entrance of the tip of the needle into the lumen is demonstrated by aspiration of blood, the sclerosing agent is injected into the vein. The needle is quickly withdrawn and the vein is compressed immediately with a gauze pad (Fig. 288). Compression is maintained by a tight adhesive strapping which is left on for 48 hours. The entire extremity is wrapped with an elastic bandage for 5 to 7 days.

Larger varices, particularly those associated with incompetent valves, can be permanently controlled only by surgical extirpation. Symptoms may be ameliorated by use of periods of rest and elevation of the extremity, as well as by use of elastic support while the patient is ambulatory. Four-inch wide elastic bandages are applied from the metatarsophalangeal joints over the heel upwards to the knee Bandages are uncomfortable if they are applied above the knee. If support of the thigh is desired, a snug elastic stocking must be used and renewed when it begins to stretch. The bandage is applied evenly and in such a way that each turn of the bandage overlaps the previous one by one-third to three-fourths of the width of the bandage. These bandages must contain rubber fibers. "Elastic" cotton bandages are unsatisfactory. Both elastic stockings and elastic bandages stretch with use and time. The stretching of a bandage may be compensated for by wrapping it more snugly. For this reason an elastic bandage is generally preferable to an elastic stocking. A woman's vanity may justify the compromise of wearing a bandage at home and a stocking when she goes out. At present attractive nylon-coated rubber stockings are available. Elastic materials may be washed but they should be dried flat to prevent stretching.

Surgical obliteration of varices of the internal saphenous system requires division of the saphenous vein at its junction with the femoral vein. The numerous branches at the groin must be divided and a generous segment of the saphenous vein removed (Fig. 289). This is performed through a longitudinal incision extending from the inguinal crease along the medial aspect of the femoral triangle. This may be done with use of a local anesthetic on ambulatory patients. In addition, one or more segments of varicose veins may be removed at lower lev-

the entrapped valves no longer function. Superficial veins tend to dilate, to thicken and, together with the communicating veins, to suffer from valvular incompetence. Pigmentation of the skin and dermatitis are prone to develop.

Persistent or recurrent edema favors development of infection[15-52] because edematous tissues containing fluid rich in protein provide an ideal culture medium, particularly for streptococci. The infection may be localized cellulitis or a more diffuse erysipeloid type of lesion. With infection, capillary permeability is increased and fluid with a high protein content enters the extravascular spaces. Fibroplasia readily develops and the edematous tissue becomes indurated, forming *elephantiasis*.[53] The edematous and fibrotic subcutaneous tissues are particularly susceptible to further infection or to injury of any type. Infective organisms may enter through interdigital epidermophytic lesions. Once infection is established, it is difficult to eradicate, as the organisms may lie dormant in the edematous tissues for many months, only to cause recurrent active inflammation. It is not uncommon for an ulcer to develop after such minor trauma as a mosquito bite.

Because of the multiplicity of factors involved it is difficult to determine the relative importance of each. This is particularly true because the same condition may develop in the absence of phlebitis —after trauma, recurrent cellulitis, lymphangitis, ankylosis, neurotrophic disorders, primary varicose veins or obesity— and the syndrome occasionally appears spontaneously without any apparent predisposing factors. The two important factors for the development of recurrent streptococcal infections are edema, which furnishes the culture medium, and a portal of entry for streptococci, such as epidermophytosis or mechanical injury.

The fact that phlebitis or any of the other predisposing factors seldom give rise to a similarly disabling condition elsewhere in the body has suggested the importance of anatomic or physiologic peculiarities of the lower leg. Arterial insufficiency has been suggested but there are no reported studies to indicate that the circulation is primarily deficient in this area. Dermal and subdermal vascular sclerosis and possible arterial insufficiency may develop after repeated infection and fibrosis.

In the erect human, even in the absence of disease, all spaces and tissues of the leg are subjected to constant high pressures (see above). Injuries to a normal leg tend to heal slowly but healing is accelerated if the patient is recumbent. Healing in the ambulatory patient may be assisted by the use of elastic compression of the leg. One may speculate as to the peculiar vulnerability of the skin and subcutaneous tissues of *the lower third of the leg*. The feet are supported and protected from injury by properly fitting shoes. The heavy fascia surrounding the muscles of the upper two-thirds of the leg may well bear the brunt of the high hydrostatic pressure at that level. In the lower third of the leg the cutaneous and subcutaneous tissues are vulnerable to external injury and, alone, must support the tissues subjected to high hydrostatic pressures. As long as the patient is erect, the unopposed high pressure constantly tends to disrupt further any break in the skin.

If, in addition, the tissues of the leg are *abnormal* (edematous, infected and fibrosed, with the lymphatics and veins obstructed), it is small wonder that wounds and ulcers heal slowly. Cellulitis which may be present before the ulcer is formed and is uniformly present thereafter, causes the characteristic pain and seriously interferes with healing. That elevated vascular and tissue pressures alone are not all-important in the postphlebitic state is evidenced by the fact that ligation of a proximal vein, such as the inferior vena cava for septic pelvic thrombophlebitis, in the absence of venous disease in the leg itself, may result in persistent high recumbent[15] and ambulatory venous pressures[14] with no discomfort, no serious complications, and little or no edema of the leg.[54]

*Symptoms.* The patient may give a history of overt thrombophlebitis or of insidious painless edema of the leg.

sive thrombosis of virtually all the veins of a leg causes severe edema, cyanosis, coldness and often subsequent peripheral gangrene. Local symptoms are severe, presumably owing to the massive venous occlusion that prevents escape of blood from the leg, and indeed even its entrance into the leg. As the clots are friable, the danger of embolization is great. Hospitalization is required.

Thrombophlebitis of a normal or varicose superficial vein results in a hard, tender venous mass with overlying redness, warmth and tenderness in the skin. The danger of embolization is slight, but ligation or excision of the vein is indicated with rapid proximal extension of the thrombosis. Treatment with phenylbutazone results in dramatic resolution of symptoms. It may be given in 100 mg. doses four times a day for 5 to 7 days.

*Importance in the Ambulatory Patient.* In many instances phlebothrombosis occurs in post-traumatic, postoperative, postpartal, febrile, inactive or bedridden patients. It is more frequently associated with severe heart disease than any other condition. Thrombosis and embolism are common in ambulatory cardiac patients. It has been suggested that the benefit derived from inferior vena caval ligation for congestive heart failure lies in prevention of embolization from the lower part of the body. As thrombophlebitis often appears from one to three weeks after parturition, operation or illness, the patient may well have become ambulant and returned home by the time the disorder develops.

Five to 10 per cent of cases of venous thrombosis occur spontaneously in apparently healthy, active persons. Either thrombophlebitis or phlebothrombosis may develop. The former sometimes is manifested simply by insidious swelling of an extremity. Phlebothrombosis is often unsuspected until embolism develops.[40, 41]

Spontaneous venous thrombosis is often recurrent and frequently involves the superficial veins.[42] Since recurrent phlebitis is commonly associated with thromboangiitis obliterans, the latter condition must always be suspected and looked for in the presence of spontaneous, particularly recurrent, phlebitis. Pulmonary emboli, recurrent at long intervals, may be associated with extending spontaneous thrombosis.

Venous thrombosis may follow unusual effort, particularly in the upper extremity,[43] or it may follow relatively minor trauma.[30] One must be cautious, however, in interpreting the spontaneous appearance of edema, or the appearance of edema after injury, as always indicative of thrombophlebitis. Edema, infection, fibrosis and ulceration may occur without any anatomic or functional evidence of venous disease.[14, 30]

### Postphlebitic Sequelae

Regardless of the circumstances at the onset, management of postphlebitic sequelae is largely an ambulatory problem. Edema, pigmentation, secondary superficial varicose veins, dermatitis, cellulitis, recurrent erysipeloid infection, fibrosis, elephantiasis and recurrent ulceration are apt to follow episodes of thrombophlebitis of the lower extremity and cause severe prolonged disability. Zilliacus[44] reported that of 690 patients with phlebitis, 6 to 14 years later 90 per cent had persistent discomfort and 20 per cent had ulcers. Jorpes[45] stated that in Sweden the postphlebitic syndrome has caused more disability than automobile accidents. This condition is preventable by prompt adequate treatment of the original thrombophlebitis.

*Pathogenesis.* The appearance and severity of postphlebitic sequelae depend largely on extent of the thrombosis, intensity of the inflammatory reaction and initial management of the acute attack. Thrombosis obstructs the veins and inflammation damages the vein walls and adjacent tissues. Whereas it was formerly believed that extensive damage occurred to the perivenous lymphatics,[21, 46–48] Kinmonth[5] has demonstrated surprisingly normal deep lymph channels in even severe postphlebitic extremities. Reflex arteriolar spasm increases the edema in the acute phases. Recanalization of the vein may occur with time but

congested. Prominent varices may extend up the thigh onto the abdominal wall.

*Diagnosis.* The foregoing findings in a patient with a definite history of an acute attack of thrombophlebitis almost certainly indicate a postphlebitic syndrome. If the initial episode was one of insidious edema, the presumption is strong that thrombophlebitis has occurred, but the entire picture may be on another basis. Edema after severe trauma may be due to complicating thrombophlebitis or to the trauma alone.[30, 57] The same clinical picture may follow any one of a number of other primary etiologic factors, such as trauma, cellulitis, lymphangitis, ankylosis, obesity or neurotrophic disorders. If the etiology is in doubt, the diagnosis may be clarified by phlebography or by determination of the venous pressure pattern on ambulation (see above).

The special tests are not necessary in all cases to evaluate chronic vascular disorders in the legs, but they will readily resolve any doubt as to etiology, and in the presence of venous disease they assist in evaluating the degree of venous hypertension.

*Differential Diagnosis.* As many other conditions may cause edema, pigmentation, dermatitis, fibrosis and ulceration, the diagnosis must be carefully established in each instance. The most reliable clinical diagnostic feature is the history of an attack of acute thrombophlebitis.

Unfortunately, postphlebitic ulcers, and other types as well, have been included erroneously in the term "varicose ulcer." Varicose veins may be mild or absent in the postphlebitic state, and the serious changes in the leg are often out of all proportion to the varicosities present. In fact, many times because of the edema the varicosities do not appear prominent and only by careful palpation can their presence be demonstrated. Primary varicose veins commonly are present for many years and become prominent before significant cutaneous changes occur in the leg. Edema is minimal or absent and subcutaneous fibrosis is uncommon. The valves in the deep system are usually competent and venous stasis is minimal. The ulcer is usually small and shallow and responds readily to supportive treatment.

Recurrent cellulitis in an apparently healthy leg may lead to pigmentation, dermatitis, edema, fibrosis and ulceration. Absence of a history of phlebitis in a patient with definite symptoms of cellulitis suggests that the cellulitis is a primary lesion. We have seen cellulitis simulate phlebitis by causing reflex sympathetic overactivity with edema, sweating, coldness and pallor. The special diagnostic tests may be employed to demonstrate a normal venous system.

Minor injuries, such as a mosquito bite, may lead to indolent ulceration. Major injuries, such as a femoral fracture, may be followed by severe edema, and eventually the cutaneous changes and ulceration may resemble the postphlebitic state. In some instances the correct diagnosis can be reached only by the special diagnostic tests previously described.

Edema and ulcers associated with ankylosis or neurotrophic disorders are classified according to the primary disorder. Ulceration associated with neurosyphilis and other neuropathies occurs on the feet, and other stigmata of disorder are present. Careful neurologic examination is helpful.

Insidious edema of a leg may be due to occult phlebitis or to primary lymphedema. Such edema frequently appears in early childhood and is referred to as congenital lymphedema. If a familial history of lymphedema is obtained, the disease is then considered hereditary congenital lymphedema (Milroy's disease[58, 59]). The edema is usually slowly progressive and as time passes cellulitis may occur and fibrosis follow. The veins of the affected extremity appear normal or are inconspicuous. The special diagnostic tests may be necessary to clarify the diagnosis.

Boyd and associates[60] described arteriosclerotic ulcers as deep, penetrating the deep fascia; because they are traumatic in origin, they occur usually over the anterior and anterolateral surfaces of the

Thrombophlebitis may have occurred spontaneously or after operation, injury, parturition or a systemic infection. Characteristically, during the acute attack symmetrical edema rapidly develops in the extremity and this is associated with pain, tenderness and fever. The leg may be white and cold (phlegmasia *alba* dolens), owing to severe arterial spasms; rarely is it red and warm. The degree of residual edema depends on the extent of the thrombosis, the severity of the phlebitis and the adequacy of initial treatment.

An asymptomatic interval of months or years may ensue. Pigmentation above the malleoli may appear insidiously or after recurrent attacks of cellulitis. Interdigital itching, scaling and cracking are caused by epidermophytosis. Itching, scaling, oozing eczematoid lesions of the leg may become severe and persistent. The superficial veins of the lower leg become moderately prominent and thickened, and valvular incompetence is demonstrable. These varicosities, which are rarely large, are more prominent in the leg than in the thigh. They may become the site of recurrent phlebitis.

In the presence of edema any portal of entry may be the means by which streptococci or staphylococci reach the tissues with resultant erysipeloid infection or cellulitis. Erysipeloid infection is frequently associated with a chill followed by fever, itching and burning of a small or large area of the leg, and a sense of fatigue and lethargy. The edematous subcutaneous tissues then become indurated and fixed. The skin is tight and scarring may reduce the swelling. Ulceration may occur spontaneously in the area of maximal change, but more commonly it follows minor trauma or infection. Pain accompanies the recurrent attacks of cellulitis and frequently becomes constant with the persistent cellulitis that follows ulceration. A "bursting pain," allegedly due to high venous pressure, has been described[35] but has been extremely rare in our experience. Usually the patient with postphlebitic syndrome is extremely uncomfortable standing and is more comfortable walking. In cases of severe venous obstruction walking may cause discomfort in the leg, apparently associated with an elevated venous pressure which rises, rather than falls, with ambulation.[56] As rest relieves the pain, these symptoms must be carefully differentiated from the intermittent claudication of arterial insufficiency. Occasionally, pain is due to persistent vasospasm, which is evidenced by coldness, excessive sweating, pallor on elevation and cyanosis on dependency.

*Physical Findings.* The chief lesions are in the lower half of the leg. Edema may be severe and involve the entire extremity or it may be minimal and involve only the lower leg or foot. Cutaneous lesions are prominent and involve the legs above the malleoli primarily but they may extend below the malleoli onto the foot. The skin may be dark brown, dry and scaly, or diffuse eczematoid lesions may weep thin serous fluid. The subcutaneous tissues are indurated over a wide area. Cyanosis and excessive perspiration may be present. The nutrition of the toes is usually good and commonly the general circulation of the leg is adequate. Scars of healed ulcers are common. Tenderness and redness are often associated with active infection. Open ulcers may be present, usually above the malleoli. These may be large and surround the leg. Their bases are dirty and firm and a copious watery discharge is common The edges may be sharp and rolled if the ulcer is progressing, or thin and flat if healing is in progress. Infection about the ulcer is common and may lead to redness, severe pain and exquisite tenderness. Varicose veins are common in the legs but may be absent. They tend to be fairly straight, thick-walled and indurated, commonly leading directly to the area of ulceration. In the areas of cutaneous induration these veins are identified as soft, linear channels running through the area of induration. Pain, tenderness and induration accompany attacks of acute superficial phlebitis.

If venous obstruction is severe the edema is more pronounced, cutaneous veins are prominent, and the leg appears

the needle and left in place as the needle is withdrawn. Twenty cubic centimeters of 1 per cent solution of Xylocaine is injected every six hours. This technique not only permits repeated blocking without requiring repeated insertion of needles but also permits use of anticoagulant therapy after the tube is in place.

Prolonged bed rest should be avoided. Early activity after application of compression bandages is the best means of preventing extension of thrombosis. Heparin rapidly relieves the acute symptoms of phlebitis and prevents extension of thrombosis.[44, 45, 61-63] It is desirable to prolong the clotting time to 3 to 4 times the normal figure. Intermittent intravenous or intermittent subcutaneous injection may be used. For prolonged ambulatory treatment substitution of one of the oral coumarin drugs is indicated.

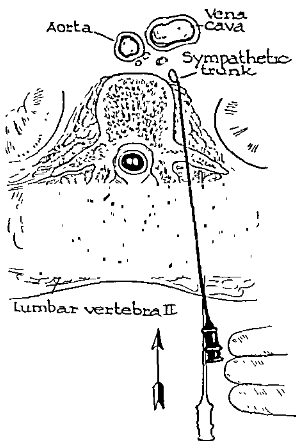



*Figure 291.* Technique of lumbar sympathetic ganglionic block. The needle is introduced perpendicular to the skin until it hits the transverse process The direction of the needle is then changed slightly either above or below and inserted for an additional two fingerbreadths. The point of the needle then lies on the anterolateral aspect of the body of the vertebra where the sympathetic chain is located.

The dosage is regulated to prolong the prothrombin time significantly but to avoid the danger of bleeding from overtreatment. Careful laboratory regulation of dosage is essential, repeated daily at the onset, later at longer intervals. However, we believe that if early ambulation is practiced, there is little indication for anticoagulant therapy, which is not without danger because of the possibility of hemorrhage. Lumbar sympathetic blocks are contraindicated after anti-coagulant therapy has been instituted, as serious bleeding may occur from vessels lacerated by the needles. With few exceptions all manifestations, including edema, promptly subside after sympathetic blocks, elastic compression and ambulation during the acute phase of thrombophlebitis.

If there is any tendency to persistent edema at the end of the initial phase of treatment, or if the acute phase of thrombophlebitis has been inadequately treated, it is imperative that an elastic bandage or a fitted elastic stocking be worn until the edema completely subsides. The patient should avoid standing quietly. Whenever he is in the erect position, he should either be walking or contracting the muscles of the leg by frequently getting up on his toes. As time goes by the residual edema usually gradually subsides. The patient should be cautioned to avoid trauma to his legs. Measures should be instituted to prevent or control epidermophytosis. If infection or ulceration should occur, they should be promptly treated. In this manner complications may be detected promptly and serious sequelae avoided.

Treatment of the established postphlebitic syndrome is largely empiric. Careful accurate evaluation of the history and physical signs will indicate the nature of the complications present. Therapy should be directed toward these complications. Edema if severe should be treated initially by bed rest. With ambulation elastic support and frequent periods of rest with elevation of the leg are indicated. Vasospasm is occasionally present and may be overcome by repeated chemical interruption of the sym-

leg. Circulatory insufficiency of the extremity as a whole is present. The ulcer usually commences as a series of small sores which rapidly coalesce to form a large defect.

At times an ulcer will develop with no apparent cause. The ulcer may persist, resist therapy, and recur without any demonstrable abnormality of the venous or lymphatic systems.

*Treatment.* Once extensive venous thrombosis with severe venous and perivenous inflammation and fibrosis has occurred, irreparable damage has been done to the leg. It has been well established that the extent of the thrombosis as well as the degree of inflammatory reaction govern, to a large extent, the appearance and severity of postphlebitic symptoms. The best treatment consists in prevention of venous thrombosis, but if thrombophlebitis has occurred, it is imperative that the extent of the thrombosis, the degree of the inflammatory reaction, and the edema be limited as far as possible.

In our experience the acute attack of deep thrombophlebitis is readily controlled by vasodilatation secured by repeated regional sympathetic nerve blocks, elastic bandage support and prompt ambulation.[39] Pain, fever and edema diminish rapidly after the first block but may recur in lesser degrees. This requires repetition of the block every day or two until the symptoms are controlled.

A lumbar sympathetic block is performed with the patient in the prone or the lateral position. Seconal, or another suitable barbiturate (½ to 3 grain), is given 60 minutes earlier The skin is prepared and four skin wheals are made with 1 per cent solution of procaine two fingerbreadths lateral to the spinous process of the first, second, third and fourth lumbar vertebrae (Fig. 290).

Matched 12.5 or 15 cm. No. 20 French needles are inserted at each point until the respective transverse process is encountered. The direction of the needle is then changed slightly, either cephalad or caudad, to permit the needle to be introduced beyond the transverse process for an additional three fingerbreadths.

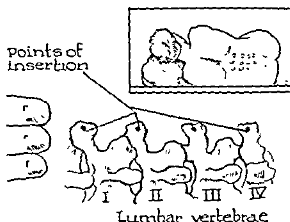



*Figure 290.* The technique of lumbar sympathetic ganglionic block. With the patient placed either in the lateral decubitus or in the prone position, points two fingerbreadths lateral to the spinous processes are chosen.

The point of the needle then lies in the retroperitoneal space on the anterolateral surface of the body of the vertebra where the sympathetic chain and ganglion are located (Fig. 291).

The transverse process is used as a landmark because, although there may be considerable difference in the thicknesses of the subcutaneous fat and the erector spinae muscle of a large, obese, muscular man and a small, thin woman, there is little difference in the thicknesses of their vertebral bodies. Eight to 10 cc. of 1 per cent solution of procaine is injected through each needle after aspiration proves the point is not in a blood vessel. It will be found that each needle will have been inserted to a slightly lesser depth than the one caudad. With a little experience, and with matching needles, it is possible to locate proper depth of insertion from impingement on only one transverse process. The remaining needles may then be easily inserted to the proper depth, forming a stair-step arrangement. This is more rapid as well as more comfortable, and is quite reliable.

In our experience use of a single needle has not proved equally reliable. However, if prolonged chemical sympathetic denervation is desired, it may be obtained by careful insertion of a large bore needle into the lumbar paravertebral space by sliding off the anterolateral margin of the vertebral body. A polyethylene catheter is threaded through

litis and dermatitis occurs which is usually caused by a hemolytic *Micrococcus pyogenes* var. *aureus*. This infection is stubborn and usually requires specific antibiotic therapy selected by sensitivity studies on bacteria isolated from the lesions. It may be necessary to change the antibiotic at intervals, as resistant organisms tend to develop. Lymphangitis or lymphadenitis due to streptococci may develop but usually responds readily to systemic administration of sulfonamides or antibiotics.

Interdigital epidermophytic lesions should be treated by careful washing between the toes twice each day. All scales are gently removed by rubbing and a fungicide, such as Desenex, is applied as a powder or ointment, depending on the moisture of the lesion. For severe interdigital lesions, or more diffuse ones involving the feet, soaking the feet for 15 minutes two or three times a day in a solution made by dissolving a 5 grain tablet of bichloride of mercury in a quart of tepid water is beneficial.

For diffuse eczematoid weeping lesions of the lower leg constant or intermittent application of dilute boric acid compresses is helpful. Bed rest is desirable. Generalized cutaneous "id" reactions may occur in the presence of fungous infections of the foot or leg. Calamine lotion may be applied to control the itching. These reactions respond to therapy directed to the local lesion in the leg and foot.

Judgment must be exercised in the care of the diseased skin of a "lower leg syndrome." If the skin is moist, it should be treated for a time by soaks or compresses to dry it out. If the skin is dry, a bland ointment, such as lanolin, should be applied locally. In the presence of ulceration, abundant secretions tend to macerate the surrounding skin and almost all ointments tend to aggravate this maceration. If the patient is in bed, the wound may be uncovered. If he is ambulatory, zinc oxide ointment may be used, as it seldom macerates the skin It may also have a specific antitryptic effect on enzymes present in the discharge from the ulcer.[65] The role cellulitis plays in precipitating and preventing the healing of chronic leg ulcers is frequently not appreciated. For severe infections, bed rest and local hot compresses of physiologic saline solution are indicated. Local application of antibiotic ointments has little or no beneficial effect in the treatment of an infected ulcer with cellulitis, and frequently causes localized sensitivity. The base of the ulcer may look better but the cellulitis is unaffected, and the maceration aggravated by the ointment may interfere with healing. An ulcer, regardless of etiology, requires either bed rest or vigorous compression therapy to promote healing. Compression is best obtained by use of the combined zinc oxide gauze and elastic adhesive boot, or, less effectively, by placing a large soft rubber sponge over the ulcerated area and then wrapping the leg tightly with an elastic bandage. For patients with a large chronic or recurrent ulcer, particularly when associated with fibrosis, more radical therapy in the hospital is required. Lumbar sympathectomy is indicated if the circulation is impaired. Appropriate obliteration of the superficial veins of the leg should be followed by excision of the ulcer down through the deep fascia and application of a split-thickness skin graft.

After deep venous thrombosis the subcutaneous veins frequently become prominent, and often varicose. Particularly in the presence of complications, it is essential that any diseased superficial veins be removed by whatever technique is required (see above) except in patients with extensive deep venous obstruction in whom it is desirable to preserve superficial veins, particularly in the thigh, because they serve as important afferent channels. This condition is suggested by a history of recurrent deep phlebitis, by severe edema and apparent congestion of the leg, and by a history that edema increases and the leg becomes more uncomfortable with walking. Under these circumstances the superficial veins should be preserved unless ambulatory pressure studies demonstrate that after constriction of the superficial veins

pathetic nerves. If the effect of the blocks is definite but only temporary and symptoms recur after a few hours, sympathectomy is indicated. Sympathectomy is also indicated in patients with generalized arterial insufficiency of the extremity, or in the presence of extensive fibrosis which it is feared will interfere with healing, after extensive surgical procedures on the veins and tissues of the leg.

Elastic support may be obtained by elastic bandages, elastic stockings or elastic adhesive tape. If the edema is soft, a good grade, 4-inch wide elastic bandage should be used until the edema is brought under control. Elastic bandages may be used alternately with an elastic stocking. A bandage should be wrapped snugly from the base of the toes to below the knee. Bandages are not satisfactory for the thigh in the ambulatory patient as they tend to bind at the knee. Elastic stockings must be well fitted and must be renewed as soon as they begin to lose their tight fit.

If the edema is brawny, and particularly if an ulcer is present, better support can be obtained by use of an elastic adhesive bandage.[64] The frequent tendency of adhesives to produce dermatitis can be obviated by use of an underlying gauze bandage impregnated with a gelatin and zinc mixture.* The leg should first be wrapped with gauze over which a 4-inch wide elastic adhesive bandage should be snugly applied from the toes to the knee (Fig. 292). This "boot" may be left on from a few days to a few weeks, depending on the character of secretions from the ulcer and the sensibilities of the patient. This is a satisfactory dressing for the badly diseased leg. Inelastic gelatin boots (Unna's paste) are less satisfactory in ambulatory treatment because they merely support the leg without compressing it. If edema can be controlled by elevation, a gelatin boot may be used to prevent recurrence of edema. Occasionally, a gelatin boot is useful in the treatment of an ulcerated nonedematous leg in which the closed form of treatment seems indicated. However, the preparation and application of a gelatin boot is a troublesome procedure. We have found the combined gauze and elastic adhesive boot simpler to apply and more effective in the treatment of the ambulatory patient.

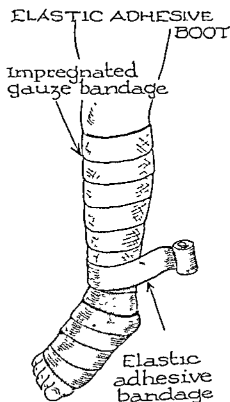



*Figure 292.* Technique of application of gelatin and zinc bandage. Impregnated gauze bandage is first applied, after which an elastic adhesive bandage is applied over this It is important that no creases are made and that the bandage is applied evenly.

Pain and tenderness frequently occur about an ulcer or in localized areas in the nonulcerated lower leg and are almost invariably indicative of cellulitis. In addition, episodes of diffuse cellulitis with pain, tenderness, redness and fever are not uncommon. This type of cellulitis is usually due to streptococci and responds readily to application of moist heat and low dosage antibacterial therapy. We customarily prescribe a sulfonamide, such as Gantrisin (0.5 to 1 gm.), three times a day until the cellulitis is controlled. In patients with chronic infection and fibrosis a course of sulfonamide therapy is repeated one week of each month for approximately one year. Less frequently, and particularly in the congested leg, a pustular type of cellu-

* Contura bandage, Medical Fabrics, Inc., Paterson, New Jersey.

appear for a few days but it is usually resolved by the tenth postoperative day. Injection of agents which will mechanically block lymphatic vessels will not result in persistent edema unless repeated injections are employed and an associated inflammatory reaction is produced.[40]

It is thus apparent that lymphatic regeneration after mechanical interruption is prompt and adequate and that lymphatic obstruction by mechanical means alone is difficult to effect. On the other hand, any type of inflammation involving lymphatics is likely to result in extensive fibrous obliteration of cutaneous lymphatic vessels or long segments of lymphatic vessels, and chronic edema usually follows.

Lymphedema results from regional lymphatic obstruction regardless of the etiology. Venous obstruction probably aggravates lymphedema. In thrombophlebitis, obstruction of both venous and lymphatic systems is present, but the relative importance of each is difficult to evaluate. Complications tend to develop with the passage of time, and the appearance of secondary infection makes these extremely serious. Partial relief of the venous stasis by recanalization of the veins does reduce the congestion of the extremity but complications frequently develop even at this stage. Some observers[10, 68] consider these complications to be due to the venous recanalization, but there is no convincing proof of this contention and serious complications develop in the postphlebitic extremity regardless of the character of the venous obstruction or recanalization.

Venous obstruction alone, without lymphatic disease, does not commonly give rise to lymphedema and subsequent elephantiasis. After ligation of the chief venous channels from an extremity with no lymphatic or venous disease (as ligation of the inferior vena cava for septic pelvic thrombophlebitis), prolonged venous hypertension and mild, frequently transitory edema of the extremity develop but lymphedema and its subsequent complications rarely appear unless venous or lymphatic disease in the extremity occurs either before or after the venous ligation. Similarly, if venous thrombosis occurs without significant phlebitis or periphlebitis, e.g., in phlebothrombosis, lymphedema and its complications rarely develop.

Lymphedema and elephantiasis may oc-



*Figure 293.* Idiopathic lymphedema in 31-year-old female. Onset of swelling at age 5 years (Courtesy of Dr. Reichard Kahle.)

the venous pressure is not increased. If the ambulatory pressure is increased with the superficial veins occluded by a tight tourniquet, the veins in the thigh should be preserved and only varicosities in the leg removed. It is particularly important that all veins in the region of an ulcer be completely removed.

For a time there was considerable enthusiasm for ligation of the deep venous system in the upper thigh[66, 67] or at the knee[19] in patients with the postphlebitic syndrome. It has been suggested[19, 68] but never proved[14, 32] that ligation of the deep vein reduces the ambulatory venous pressure in such cases by obliterating a segment of the recanalized, nonvalvular deep system. Ligation of the deep venous system is considered unsound for several reasons. Postphlebitic complications have not been regularly correlated with recanalized deep veins[69] If venous obliteration is to reduce ambulatory pressures, it is necessary to postulate the development of collateral venous channels with competent, unidirectional valves. Some valves must become incompetent in collateral channels for them to act as a shunt, and any considerable increase in the blood flow through a small venous channel would so dilate the channel as to render all valves incompetent. It is impossible to conceive of any other means by which vein ligation would reduce venous pressure, ambulatory or otherwise, distal to the ligation. There is a strong likelihood that venous pressure increases after ligation, and we have found this to be true in clinical cases studied by us.[14]

Whatever therapy is employed, it is imperative that the leg be protected from further edema and trauma and that infection be prevented or treated promptly and vigorously. Elastic support should be worn as long as there is edema. Antibacterial treatment should be continued periodically until all infection is eradicated. The patient should be cautioned to protect the leg, and he should report regularly to his physician for observation and counsel. If such a reasonable and persistent regimen is followed, the patient can be kept comfortable and free of disabling complications. If the patient is discharged from observation, recurrence of the previous difficulties in an aggravated form may be expected. With proper care, even though the leg rarely becomes normal, the patient can be made comfortable and can usually resume his former occupation. The only real solution lies in prevention or prompt adequate therapy of the initial thrombophlebitis. Too frequently, the physician minimizes the significance of edema and tells the patient it can be disregarded. Edema always must be considered as hazardous, because if not controlled, it may be responsible for the development of the "chain reaction" ultimately leading to irreversible elephantiasis. On the other hand, edema almost invariably can be controlled and the other postphlebitic sequelae prevented.

Many of these complications may appear in a leg in the absence of any type of venous disease. The treatment as outlined may be applied empirically to the complications of infection, edema, ulceration, etc., as they appear in the individual case. Again, careful follow-up therapy is indicated, depending on the seriousness of the pathologic conditions present.

## DISEASES OF LYMPHATICS

Inflammatory and obstructive lesions of the lymph vessels and nodes are common and may cause prolonged severe disability. Some lymphatic disorders are readily recognized, but many are poorly understood and in some instances may be completely unsuspected. In a series of cases of idiopathic lymphedema of the legs Kinmonth and Taylor[70] demonstrated numerous dilated, tortuous, incompetent lymphatic channels with no evidence of lymphatic obstruction.

There is abundant experimental[4] and clinical evidence that simple mechanical injury to lymphatic vessels is followed by prompt regeneration of the lymphatic vessels with early restoration of normal function. It has been demonstrated experimentally[4, 71] that when all lymphatic vessels and all but one of the major veins to an extremity are divided, edema will

phatic vessels, as in radical dissection of the axilla, is well tolerated unless complicated by infection or recurrent malignant disease. In such cases severe lymphedema may develop. If radical dissection of the inguinal glands results in prolonged lymphorrhea, infection is likely to occur and severe lymphatic stasis often follows.

The appearance of infection in an extremity in which lymphedema exists is of serious import, regardless of the underlying cause of the lymphedema. The exudation of protein-rich fluid from the injured capillaries produces an even better culture medium for the growth of streptococci, and the resultant infection causes severe fibroplasia which results in permanent thickening of the subcutaneous tissues, some of which is due to the scar itself and some to entrapped tissue fluid in the meshes of fibrous tissue. The fibrosis further interferes with both the afferent and the efferent circulation in the tissues, which become peculiarly vulnerable to injury. Indolent ulceration is the common sequel. Once infection has occurred, even though the acute episode has subsided, the bacterial organisms tend to remain dormant in the area for long periods of time. Frank cellulitis may recur spontaneously or after simple trauma.

### Treatment

Since lymphedema results from extensive obliteration of lymphatic channels, restoration to a normal condition will rarely be possible once the condition has developed. Whenever surgical or traumatic interruption of the lymphatic system occurs, every effort must be made to prevent infection which will lead to extensive lymphatic obliteration.

Any inflammatory lesion involving the veins or lymphatics of an extremity should be treated vigorously and persistently to minimize the residual effects. Treatment of thrombophlebitis has been previously discussed. Primary infections of the lymphatics or lymph nodes should be combated by complete rest of the part, local application of moist heat, and appropriate vigorous antibacterial therapy. The tendency to edema should be minimized by early elevation and by elastic compression of the part when ambulation is resumed. Compression should be continued as long as there is any tendency to edema. Suppuration indicates prompt drainage. With more than minimal suppuration of lymph nodes excision is required; otherwise, prolonged and disabling drainage will occur.

In lymphedema every effort must be made to avoid infections in the area and to treat them promptly when they occur. The edema should be controlled as well as possible by frequent periods of rest and elevation of the extremity during the day. The use of elastic compression should be encouraged but patients frequently will not continue compression in the absence of symptoms, and particularly in hot weather. For edema extending above the knee an elastic bandage is tolerated poorly as it tends to bind at the knee. An elastic stocking is less effective but more comfortable. In any case the stocking or bandage must be renewed whenever its elasticity is lost.

If the extremity becomes severely swollen, and particularly if elephantiasis develops, the only recourse is ablation of the diseased subcutaneous tissues by a modified Kondoleon operation requiring hospitalization.

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cur without demonstrable venous disease (Fig. 293). Careful study of congenital lymphedema shows no venous obstruction or evidence of valvular incompetence. The development of elephantiasis in such patients is, however, similar to that after phlebitis, in that the infection in the protein-rich edematous fluid results in massive subcutaneous fibrosis. The principal difference in the two conditions is the mechanism by which the edema is produced. In classic tropical lymphedema due to filarial obstruction of the lymphatic channels and in the elephantiasis which develops secondary to bacterial infection of these tissues, there is also no evidence of venous disease.

We have observed, particularly in the Charity Hospital patients in New Orleans, chronic ulcers often associated with lymphedema after trauma, infection or other etiologic factors in which venous disease was absent It is our impression that the warmer the climate (probably because of the greater incidence of epidermophytosis) and the more primitive the population, the more frequent will be the appearance of chronic ulcers of the leg not associated with demonstrable lymphatic disease.

The swelling of lymphedema may be severe, but it is characteristically soft and "pitting" and tends to diminish on recumbency. Such tissues are peculiarly susceptible to recurrent bacterial infection due to coccal organisms. Lymph normally closely resembles interstitial fluid in composition[72] and contains protein in a 1 per cent concentration. If infection occurs, fluid with a high protein content escapes across the capillary boundary, raising the edema fluid protein concentration to 3 to 4 gm. per cent.[50] In this protein-rich medium persistence of the infection is likely, and fibrosis develops rapidly and results in induration and contraction of the tissues. This is elephantiasis, a much more serious and disabling condition than lymphedema. Although it was originally thought that filarial obstruction of lymphatics and lymph nodes alone gives rise to tropical elephantiasis, all observers now agree that elephantiasis does not result unless secondary bacterial infection occurs in the edematous tissues.[50, 51, 73]

There is a significant difference between chronic edema due to systemic, nutritional, renal or cardiac disease and lymphedema due to stasis from localized disease of the lymphatic system. Actually, the edema is more extensive in cases of "systemic" edema because it is present in all the soft tissues of the extremity, but the lymphatic vessels are undamaged and function normally.[4] In lymphedema the edema is limited to tissues superficial to the deep fascia. The cutaneous and subcutaneous lymphatics are severely damaged and function poorly. Although there is some danger of recurrent infection in the edematous legs of patients with heart disease, more commonly the edema may persist for months or years without significant local complications.[74] Because serious complications occur much more commonly with lymphedema, the actual disease of the lymphatic system with fibrotic obliteration of the regional lymphatic channels must be of considerable significance.

### Infections

Acute infections of the cutaneous and subcutaneous lymphatic vessels occur after introduction of bacteria, usually streptococci, through the skin as a result of injury or commonly through cutaneous lesions produced by fungi or other agents. The inflammation spreads rapidly along the lymphatic trunks giving rise to tender, hot, red streaks with moderate edema of the overlying skin and secondary swelling and tenderness of the regional lymph nodes.

Suppuration is rarely associated with lymphangitis but is a complication of lymphadenitis. Lymphangitis is manifested by a sharp, often alarming, systemic reaction of fever, chills, malaise and prostration. Fortunately, the streptococci usually respond promptly to sulfonamide or antibiotic therapy. Although rare, permanent lymphatic obstruction with edema may follow suppurative lymphadenitis.

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Glomus tumor
Hemangiopericytoma
Multiple tumors arising in systemic deficiencies
Benign
Rendu-Osler-Weber's disease
Sturge-Weber's disease
Lindau-von Hippel's disease
Hemangioma unius lateralis
Malignant
Kaposi's sarcoma

LYMPH VESSEL TUMORS

Benign
Simple
Cavernous
Cystic hygroma
Malignant
Lymphangiosarcoma

## TUMORS OF THE BLOOD VESSELS

### Benign Hemangiomas

#### *General Considerations*

Hemangiomas, which are benign vascular nevi, are the most frequent of all tumors of the blood vessels. About 75 per cent are apparent at birth and at least 85 per cent are evident by the end of the first year of life. Many of those that seem to develop in the course of the first year of life were probably present at birth but were so small that they were overlooked.

Hemangiomas are predominantly lesions of women, the ratio of females to males in some series being 2:1 and sometimes 3:1. The precise reason for the sex predilection is not clear, although the tendency of hemangiomas to become apparent, or to increase rapidly in size, with the onset of menses or early in pregnancy suggests a possible relationship to the female sex hormones. According to Watson and McCarthy,[4] hemangiomas are uncommon in Negroes. The records of Charity Hospital of Louisiana at New Orleans for the period 1947–1953 show that 41 of the 107 recorded cases, about 38 per cent, occurred in this race. Over the same period the hospital population was approximately 60 per cent Negro.

Hemangiomas most often occur in the head and neck. In Watson and McCarthy's study of 1363 individual tumors of the blood and lymph vessels in 1001 patients at Memorial Hospital, 952 were classified as hemangiomas and 56 per cent of these occurred in the head and neck. The localization is more striking if it is remembered, as these authors pointed out, that these areas constitute only one-seventh of the total body surface.

Slaughter preferred to consider hemangiomas as vascular anomalies rather than true neoplasms, on the ground that their size is predetermined and their growth self-limited. It is true that they grow as the child grows, and that the enlargement which occurs in lesions not treated early is often to be explained by the natural development of the patient rather than by active neoplasia.

Four congenital neurocutaneous syndromes are known to occur in association with hemangiomatous growths in certain areas: von Recklinghausen's disease (neurofibromatosis) occurs with hemangiomas of the skin; Bourneville's syndrome occurs with tuberous sclerosis, Pringle's disease and regional hemangiomas; Sturge-Weber's disease occurs with encephalofacial hemangiomatosis; and Lindau-von Hippel's disease occurs with hemangiomatosis of the retina and cerebellum.

Malignant changes may occur in any variety of hemangioma but they are extremely uncommon. They are also usually difficult to diagnose both grossly and microscopically. Certain lesions may be benign microscopically but malignant by position, as Brown and Fryer[5] expressed it, and by clinical course, or they may be deceptively benign clinically and malignant under the microscope. Whether tumors found to be malignant begin as such or go through a preliminary benign stage is not yet known.

Stout,[6] in a consideration of blood vessel tumors "featuring vascular endothelial cells," discussed the variety termed benign metastasizing hemangiomas. The clinical course of these tumors suggests malignancy in that the original lesion is followed by the appearance of others in other locations, but there is no pathologic confirmation of the concept of metastases. Stout's idea is that serial sections of the primary tumor might show

*Chapter 20*

# Tumors of the Blood and Lymph Vessels

*By H. Reichard Kahle*

Benign tumors of the blood vessels are fairly common, which is not surprising, in view of the ubiquity of these vessels and their complex development. Malignant tumors, on the other hand, are relatively uncommon, which is surprising, because, in addition to the considerations just mentioned, the endothelium is frequently called upon, in wound healing, for the physiologic processes of regeneration and infiltration.

Vascular tumors, either of the blood vessels or of the lymph vessels, may be superficial and external or deep and internal When they are located in the internal organs, they require major surgery. Only superficial tumors, chiefly those located on the head and neck, can be managed by measures that fall under the definition of minor surgery. The surgeon who undertakes to treat them, however, whether in the office or hospital, would do well to bear in mind Slaughter's[1] warning that, although from the point of view of surgical maneuvers the treatment of superficial tumors of the head and neck may be minor surgery, the consequences of surgical error may be major.

This warning is particularly necessary in a discussion of vascular tumors in a textbook of minor surgery. Their diagnosis is usually an office matter, and the treatment of superficial tumors may safely be conducted in the office. The fact, however, that it is convenient to discuss superficial and deep tumors under a single heading offers no warrant for going beyond the limits of caution and safety in the management of these conditions. Major surgery must never be undertaken except in a hospital, and a good deal of surgery that is classified as minor had best be done there also.

## Classification

There is no generally accepted classification for vascular tumors. Some groupings which have been rather widely employed have little logic. Pack and Miller's[2] classification is comprehensive but not all-inclusive. Hertzler[3] divided blood vessel and lymphatic tumors into two large groups, (1) the hemangiomas, which include the capillary, venous and cavernous types, and (2) the *lymphangiomas*, which include simple and cavernous lymphatic tumors and cystic hygromas. This is a tempting classification because of its simplicity, but it is too great an over-simplification of a problem that is actually extremely complex.

The classification used in this chapter and outlined below is proposed as reasonably inclusive and as meeting most of the objections that have been raised to existing classifications. It might be added that much of the difficulty in existing classifications arises from the over-lapping nomenclature employed by various observers rather than from actual problems of classification.

BLOOD VESSEL TUMORS

- Tumors of endothelial cell origin
  - Benign
    - Arterial hemangioma
    - Capillary hemangioma
      - Spider hemangioma
      - Sclerosing hemangioma
    - Cavernous hemangioma
    - Cirsoid (racemose) hemangioma
  - Malignant
    - Solid endothelioma
    - Hemangiosarcoma
- Tumors arising from the neuro-myo-arterial capillary shunt

ficial hemangiomas, is necessarily surgical, but, as already intimated, it is not always minor surgery. The procedures required are often of great magnitude. Judgment and technical skill are essential, both in the primary excision and in the plastic repair which is usually required. The vascularity of these tumors is frequently entirely out of proportion to their size and innocent appearance, and their vascular attachments must be controlled before their removal is attempted.

Macomber listed the general indications for surgical treatment of hemangiomas as follows:

1. When the tumor is so large that it cannot be removed or destroyed by physical agents.

2. When the tumor grows faster than the patient, especially if it bulges when the child strains or cries.

3. When fragile tissues and venous stasis are associated with ulceration or hemorrhage.

4. When the patient is unwilling to continue to accept the existing disfigurement and clearly understands that operation may leave a scar but is willing to take the chance.

5. When other treatment has failed or has left disfiguring, dangerous or potentially dangerous tissue changes.

Excision must always be well beyond the limits of involvement in order to prevent recurrence. This means that if the tumor is extensive, an unsightly scar is likely to be left and further, reconstructive surgical procedures will be indicated. Watson and McCarthy considered that the proneness of patients with vascular tumors to keloid formation is another disadvantage of surgical removal. Other observers do not seem to have been impressed by this possibility.

### *Special Types*

***Arterial Hemangiomas.*** The variety of hemangioma known as hemangioma simplex or the strawberry birthmark (Fig. 294) is almost always arterial. At birth the tumor is usually represented by a flat, red spot, which is likely to enlarge rapidly and which may become raised and irregular. Sometimes it is possible to notice the increase in size from one day to the next, and it is not unusual to hear parents say that the mark expands with each beat of the heart.

Arterial hemangiomas, when they begin to grow, are soft, compressible and bright red, as might be expected because of their arterial origin. When palpation is added to inspection, the bulk of the tumor may be felt as a firm mass spreading out into the surrounding and deeper tissues. These tumors are often multiple, and parents must always be cautioned to watch for the development of additional tumors and to report them at once.

There is no justification for delay in the treatment of arterial hemangiomas, since they characteristically progress. Therapy should be prompt and definitive. The ideal, as Brown and Fryer expressed it, is control of the tumor without injury to, or disturbance of, the growth of the surrounding parts, and with the least possible scarring.

The best treatment for a small arterial tumor located in an area in which scarring is not of great consequence, if seen promptly, is electrocauterization with a fine point or surgical removal. If tumors are treated in this manner while they are only a few millimeters in size, many later, major problems would be avoided.



*Figure 294.* Hemangioma simplex (strawberry birthmark).

atypical endothelium, with free vascular anastomoses, and that careful staining might show a delicate framework of reticulin fibers. With these findings, such a tumor would fit into his own classification of a malignant blood vessel tumor, and the terminology, as Brown and Fryer noted, would negate his nomenclature, which in itself is a contradiction in terms.

In dealing with hemangiomas we must always bear in mind that apparently superficial tumors may be associated with similar, more deeply seated vascular lesions and may represent only a single phase of a widespread developmental defect. The possibility also exists that these tumors may sooner or later present such complications as hemorrhage, infection, ulceration or, as just noted, malignant change. More important in the usual case, however, particularly when the patient is a girl, is the psychic effect of facial disfigurement. It is ironic that the port-wine stain (nevus vinosus), which from the standpoint of possible tissue changes is least capable of harm, can, because of its extent, cause the most serious psychic difficulties.

### *Principles of Therapy*

Hemangiomas occasionally undergo spontaneous regression, either because they outgrow their blood supply or because thrombosis follows infection Sometimes the reasons are not apparent. If regression occurs, it is usually at the time of the first or second dentition. Some observers[7] are so convinced of this possibility that they consider it safe to leave many simple hemangiomas untreated. Brown and Fryer, on the other hand, said that it is unfortunate that the "friendly" terminology of strawberry marks and birthmarks has developed. They thought the chances of progression of these tumors are so great that it would be safer if parents were told that the lesion is a hemangioma or blood vessel tumor and is very likely to require treatment. They also emphasized that one of the dangers of waiting to see what is going to happen is that a whole feature may be sloughed off and reconstructive surgery may become necessary. Another danger is that the tumor may become uncontrollable and endanger life.

The best plan of management is selective. If the tumor is superficial and readily accessible, immediate treatment is probably the wisest plan. Otherwise, careful observation is justified as long as progression is not evident. A primarily arterial tumor is likely to require prompt treatment. Expectant measures are justified if the tumor is primarily venous.

Hemangiomas, theoretically, should be easy to treat, for they respond well to a number of therapeutic procedures. In practice the situation is not that simple. Effective measures may be followed by undesirable or actually dangerous sequelae, whereas those free from such objections are often contraindicated by the circumstances of the special case, particularly the size, location or vascularity of the lesion to be treated.

The objective of both cryotherapy and irradiation is the same: obliteration of the vessels that make up the tumor by producing damage to their endothelial lining with consequent sclerosis and organization. Such techniques as use of carbon dioxide snow or injection of sodium morrhuate, even when they are successful, may result in so much scarring that later excision of the scar and reconstructive surgical procedures may be necessary.

Irradiation must be used with caution, even when the lesions are radiosensitive, as not all hemangiomas are. It is highly dangerous when it is used near specialized tissues such as the lens and the cornea, which are particularly radiosensitive. It is also contraindicated in infants and young children, whose life expectancy (now 60 to 80 years) is far too long to permit radiation effects to exist. If this technique is used in young children, the dangers of subsequent malignant change are so real that irradiation should be followed by later excision of the treated area. Even in older persons telangiectases and malignant change may follow this form of therapy.

The treatment of deep and extensive hemangiomas, as well as of certain super-

possible "glazy" scars, mentioned that Carroll reported good results with the use of dry ice.

Excision followed by skin grafting is the best treatment for heavier, darker types of lesions on exposed surfaces. Results are variable, and the patient should therefore be made to understand, before operation is accepted, that the result may be merely the substitution of one form of disfigurement for another, since grafts and flaps about the face have less mobility than in other parts of the body. For this reason, if the lesion is light-colored and not very conspicuous, it is sometimes best merely to leave it alone, and to advise the patient to obliterate it with Cover-mark. Men and boys, as Brown and Fryer noted, often will not accept this advice. Lesions that are not on visible surfaces can usually be left alone.

Pack and Miller described the abrasive technique recommended by Jönsson, by which sandpaper is used to destroy the capillaries in the skin, leaving the cutis undamaged. Brown, who was the first to use tattooing, at Valley Forge General Hospital, now has decided reservations about the method, because of the tendency of the white pigment to be absorbed and the considerable surface scarring.



*Figure 295.* Capillary hemangioma of left side of chest.

Conway and Docktor[3] reported good results with it. This is an ingenious method, but it is clearly suitable only for selected cases and it requires specialized equipment as well as specialized personnel.

Port-wine stains are not radiosensitive and require such heavy doses for good results that new problems are introduced, particularly development of irradiation dermatitis, which may progress to malignant change unless the treated area is excised and plastic surgical procedures carried out.

*Spider Hemangiomas.* Spider hemangiomas, which are fairly frequent, begin in childhood as single, small, flat, red dots. They may never increase in size but they may also, at any time, begin to grow by production of fine radiating vessels. These vessels are smaller than the parent vessels and often can be seen only with the magnifying glass.

Tumors that show no evidence of growth may safely be left alone unless treatment is indicated for cosmetic reasons. Any evidence of growth is an indication for treatment. It is well to begin conservatively, by attempting preliminary destruction of the central feeding vessel with the small cautery. If the radial vessels disappear, no further treatment is necessary. If they do not, surgical excision is required, with plastic repair as indicated. Spider hemangiomas are not radiosensitive.

*Sclerosing Hemangiomas.* Sclerosing hemangiomas are described by Gross and Wolbach[9] as vascular tumors in which, as the result of an overgrowth of stroma, a process of sclerosis occurs, with accumulation of fat and hemosiderin. These authors observed 67 such lesions in 66 patients. They occur, typically, in older persons. In 80 per cent of this series the patients were between 10 and 59 years of age, and 44 per cent were between 30 and 49 years of age. The obvious inference is that the sclerotic process takes years to develop.

Sclerosing hemangiomas are commonly limited to the skin and subcutaneous fat, and two-thirds of them appear on the extremities. They are hard, flat lesions,

This method is almost always effective in small tumors. Use of carbon dioxide snow or injection of boiling water or sodium morrhuate is less uniformly successful and may be attended with so much scarring that secondary operation is necessary.

Application of either radium or roentgenotherapy is a satisfactory form of treatment if the hemangioma is located on a flat surface. There are, however, technical difficulties associated with these methods It is hard to hold young children in position for roentgenotherapy. It is also hard to hold radium in position when the lesion is on the eyelid or the nose. If the tumor is deep, the possibility of damage to underlying epiphysis or cartilage must be considered when radiation therapy is used.

Brown and Fryer, who discussed these various difficulties and hazards, stated that the advantages of irradiation can be secured and its dangers avoided by use of interstitial irradiation in minimal dosages, 1/10 millicurie gold radon seed for each cubic centimeter of lesion, which is considerably less than has previously been recommended. A second treatment is sometimes necessary, but it is quite possible that in some cases, if surgical therapy is also employed, activity may be controlled by even lower dosages. The application is made through hollow introducer needles, which are placed in small stab openings outside the neoplastic area. Several needles can be placed through each stab incision. With this method the overlying skin is usually spared, though it may become wrinkled, and plastic surgical procedure may be required later for cosmetic reasons This technique introduces no danger of damage to cartilage and other sensitive structures. Growth distortion, which is always a risk when larger dosages are used, apparently is also eliminated with these smaller dosages. The possibility of a chronic radiation lesion, which later in life may require resection and plastic repair, cannot, of course, be excluded.

Brown and Fryer called attention to the studies now in progress on the use of subcutaneous linear threads made suitably radioactive with cobalt or phosphorus. It is important, again, to keep the dosage at a low level, one-tenth or less the dosage used for malignant lesions.

Surgical excision is the method of choice if the lesion is too large to be destroyed by other measures or if other measures, for one reason or another, are contraindicated. If the lesion is on the face, there must be sufficient tissue left after excision to permit primary closure of the wound without distortion of the features. If this cannot be accomplished, a graft may be necessary. Another possible method of treatment is temporary control of the lesion by interstitial irradiation, as already described, with later skin grafting when the child is older and a more satisfactory plastic procedure can be carried out.

*Capillary Hemangiomas.* Capillary hemangiomas, both grossly and microscopically, consist of dilated superficial capillaries which give the skin a characteristic port-wine appearance (Fig. 295). The affected vessels, which are located abnormally close to the skin, may become thickened and more prominent as the patient grows older. This is not, however, a progressive or destructive type of vascular tumor.

For these reasons, it is safe merely to observe capillary hemangiomas that are located in areas difficult to treat, so long as they remain stationary. Larger, growing tumors should be treated promptly. Small, superficial tumors are best treated by carbon dioxide snow. This method is often extremely effective and is so simple that it can be carried out in the office. An easy way to make the application is through a hole cut in a blotter, which is held firmly against the surrounding uninvolved areas and thus protects them against the effects of the snow. Each application should be limited to 10 to 20 seconds; a longer application may cause scarring and ulceration. At least three treatments, at intervals of 2 to 3 weeks, are usually required, but as many as eight or ten may be given safely. Brown and Fryer, who were not enthusiastic about this method because of

success in lesions in which the blood flow is brisk unless preliminary ligation of the arterial connections is undertaken. Watson and McCarthy, who considered injection the method of choice, believed that if the lesion is not controlled after two or three treatments, surgical intervention should be undertaken without delay and regardless of the location of the tumor.

Irradiation in safe dosages has no effect on a cavernous hemangioma except on the small vascular components, which are radiosensitive. The larger components are not, though clotting in them sometimes follows the destruction and scarring of the smaller vessels. Interstitial irradiation, which conserves the underlying skin, is sometimes useful as a preliminary measure before surgical excision.

Brown and Fryer revived the multiple suture obliteration method, which consists in introducing chromic catgut into the large vascular channels through the skin. After the sutures are tied on the surface, a pressure-fixation dressing is applied and kept in position for several days. The objective of the method is to collapse the dilated venous channels and spaces and promote obliteration of the vascular supply by stasis of the blood flow and the mild inflammation induced by the presence of the catgut. Since the sutures do not cut off all the surface blood supply, sloughs are unlikely. On the other hand, channels that have been closed may reopen, and the procedure may have to be repeated. Brown and Fryer pointed out that this is a method which can be used to control the lesions and preserve the features, and they recommended it as an adjunct to more radical methods of treatment when there is extensive involvement of the extremities. This is also a useful method in lesions about the genitals, in which irradiation is contraindicated. Brown and Fryer recommended staged surgical procedure for tumors in this location.

Since cavernous hemangiomas, especially if they are extensive, tend to become lumpy, solid and unsightly, with associated thickening of the features, their removal from the face and neck is often an economic and social, as well as purely a cosmetic, consideration. Radiation therapy gives particularly poor results in these locations.

Lesions of the face, skull and neck may be both superficial and deep, and Brown and Fryer emphasized that what they called malignancy by position must be



*Figure 297.* Cavernous hemangioma of extremity.



*Figure 298.* Cavernous hemangioma of neck associated with capillary hemangioma of lip.



*Figure 296.* Cavernous hemangioma. (Photo on right from Echols, D. H., and Kleinsasser, L. R. J: Cavernous hemangioma of the skull. Am. J. Surg., *40*:134–136, April, 1943)

which may be gray, pinkish gray, yellow or tan. The pathologic appearance varies from case to case. In 18 of Gross and Wolbach's cases giant cells had phagocytosed the lipid and hemosiderin present. Malignant changes are occasionally observed.

Sclerosing hemangiomas grossly resemble nevi but can be distinguished microscopically by the stellate arrangement of fusiform cells with connective tissue cells enclosing neurofibrils between the clumps. The preoperative diagnosis is seldom correct. In addition to being mistaken for nevi, they may be confused with fibromas, neurofibromas or sebaceous cysts If they are deeply pigmented, they may be confused with melanomas If they are filled with fat, they may be mistaken for xanthomas. In a recently observed case, in which the lesions were on the leg and were bilateral, one tumor was diagnosed as a nevus and the other as a fibroma. The correct diagnosis was made microscopically.

All pathologists do not accept Gross and Wolbach's classification of these tumors. Some, like Sternberg,[10] prefer to regard them as histiocytomas, a variety of skin tumor in which the histocyte is the predominant cell. If a histiocytoma is extremely vascular, it may give the impression that it is of capillary origin.

*Cavernous Hemangiomas.* The vascular tumor known as a cavernous hemangioma consists chiefly of veins and venous spaces containing venous blood. The arterial element, if present at all, is small. Although these are not true neoplasms, they show a definite tendency to become larger.

Grossly this lesion is a soft, compressible, bluish mass, which does not pulsate but which has a characteristic consistency because of the large veins and venous spaces of which it consists (Figs. 296, 297, 298). Microscopically the components are seen to be thin-walled venous sinusoids, with a variable number of smaller vessels

Cavernous hemangiomas may occur anywhere in or on the body. They are relatively frequent in the muscles, the liver and the vertebral bodies. When they occur on the buccal mucosa, some relation to fifth nerve distribution may be evident. The affected portion of the body may show overgrowth; an increase in the length and circumference of the bones of the extremities is not unusual.

The preferred treatment for small cavernous hemangiomas is injection of sclerosing substances such as sodium morrhuate, Sylnasol or urethane. If conditions permit, the ideal plan is to make the injection into the lumen of a vascular sinusoid. If it must be made into the interstitial tissues, care must be taken to prevent necrosis, by using smaller injections and causing less pressure. The injection method has little chance of

lesion include lowering of the diastolic pressure as the result of decreased peripheral resistance; an increase in the circulating blood volume; and cardiac enlargement, affecting both the right and left ventricles. These effects are not nearly as pronounced as they are in acquired lesions, perhaps because development of congenital lesions is more gradual; since the abnormal state exists from birth, there is better adaptation of the cardiovascular mechanism to it.

It is easy to understand why these lesions are sometimes called "hot varicosities." Their appearance suggests a mass of worms beneath the skin. The dilated vessels pulsate, a thrill may be felt in them, and a murmur, hum or roar may be heard on auscultation over them. If the communications between the arterial and venous circulation are extensive, cardiac enlargement (Figs. 299 and 300), as just noted, may occur, as in traumatic arteriovenous fistulas. Compression of the tumor, with obliteration of the communications, may produce a characteristic slowing of the pulse (Branham's sign). It may also result in other characteristic changes, including a rise in the diastolic pressure, a change in the cardiac murmur if one is present, and a contraction of the cardiac shadow on fluoroscopy.

Treatment of the cirsoid type of vascular lesion is very far removed from minor surgery. Control of bleeding at operation is the first consideration and often presents major difficulties. Ligation of the proximal artery alone is not sufficient. In lesions of the extremities ligation of the major vessel supplying the communication and the use of a standard tourniquet may be adequate. For lesions located elsewhere the methods may include insertion of multiple sutures from the surface by the technique already described; plugging of the venous ostia by muscle, as recommended by Gage;[12] or elevation of a skin flap and removal of the lesion from its undersurface, which is particularly suitable for lesions in the scalp. Many attempts at surgical excision have ended in amputation. The fatalities which sometimes occur in amputation for arteriovenous communications are explained by Gage[13] as due to the tremendous blood flow in the marrow cavity of the bone, which is not, of course, controlled by the tourniquet.

### Malignant Endothelial Cell Tumors

McCarthy and Pack[14] made an important and practical point when they called attention to the habit some pathologists have of using the term hemangio-endothelioma to denote both benign and malignant lesions. This is loose and dangerous nomenclature. To clinicians, the term implies a malignant tumor, and amputations for benign lesions have been narrowly averted—and may have occurred—because of this misunderstanding.

The promiscuous use of the term endothelioma has given rise to much of the confusion that now exists concerning malignant vascular tumors. The confusion would be clarified if the term were used only with specific qualification. Many pathologists believe that it would be best to drop the term endothelioma altogether, substitute for it the generic term angiosarcoma and term the growth a hemangiosarcoma or a lymphangiosarcoma according to the findings in the special case. The tumor that Stout[6] called a hemangio-endothelioma would, under this plan, be called a hemangiosarcoma.

*Solid Endothelioma.* The solid endothelioma might better be termed an infiltrating cellular hemangioma. It is characterized by a preponderance of solid, typically endothelial cells with relatively few vascular channels. It is a sort of twilight tumor. The endothelial cells proliferate so that they fill, or almost fill, the lumens of what would be a benign hemangioma except for this cellular overgrowth. The infiltrative properties of this tumor are evident in the deeper structures, but not in the skin, in which it is completely innocuous, in spite of the wild look of the cells that fill the capillary lumens. It does not metastasize, and Brown and Fryer well expressed its properties when they called it malignant by position. In many respects it suggests

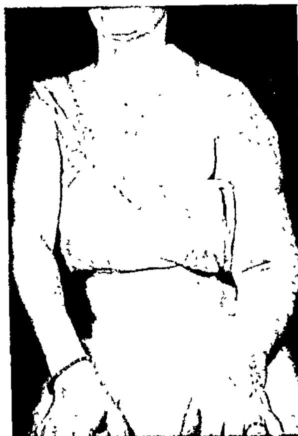


Fig. 299.



Fig. 300.

*Figure 299.* Congenital arteriovenous aneurysm involving left upper extremity. Although patient had been operated upon previously, there was extensive recurrence.

*Figure 300* Photograph of patient, shown in Fig 299, nine months later Shortly after photograph in Fig. 299, was taken, patient was operated upon and extensive communications were divided. However, there was massive recurrence by opening of new arteriovenous communications.

reckoned with in such cases. The microscopic picture may be benign but the whole temporal fossa may be filled with channels extending into the deep facial tissues and even into the cranial cavity.

*Cirsoid (Racemose) Hemangiomas.* Cirsoid or racemose hemangiomas are congenital arteriovenous communications made up of a mixed plexus of dilated and tortuous intercommunicating arteries and veins. They are not neoplastic and are best explained on an embryologic basis. Both arteries and veins arise through differentiation from a common capillary plexus. In certain embryologic vessels the direction of the blood flow may be reversed, so that vessels that function as arteries during one stage of development function as veins during another. Acceptance of this concept also satisfactorily explains the multiple communications usually observed.

Arteriovenous communications usually progress rapidly, by an increase in the arterial connections or by new development, until adolescence. Then they progress more slowly or remain stationary. They are most often observed in the extremities, the neck, the scalp and the intracranial region.

Pemberton and Saint[11] described the effects of congenital arteriovenous communications as local, regional and general. The local effects are dilatation and thickening of the distal veins and thinning and dilatation of the proximal arteries. The regional effects are threefold, (1) hypertrophy as evidenced by an increase in the girth and length of a limb, (2) an increase in the superficial temperature, and (3) trophic changes. Local and regional effects are much the same in the congenital and acquired types of arteriovenous communications. General effects of the abnormal communication in the congenital type of

by a rich network of sympathetic nerve fibers and nontypical muscle fibers. Its function is apparently maintenance of a constant capillary pressure and control of peripheral temperatures by regulation of the blood flow.

*Glomus Tumors* (see also p. 117). Glomus tumors, as Kolodny[15] observed, were recognized for many years before they were described histologically by Masson,[16] in 1935. Masson selected the name because of the histologic resemblance of the tumor to the glomus coccygeum of Luschka. Bailey[17] considered glomangioma a better term.

In about half of all cases there is a history of trauma. Most reported tumors have been on the digits, but they may appear anywhere on the body. In the 17 cases reported by Lewis and Geschickter[18] the location was a digit in only 3 cases. The other tumors were variously located on the knee, forearm, thigh, leg, elbow, palm and wrist (Fig. 301).

The original lesion is usually described as a small bluish or reddish nodule. Kolodny took exception to this description, on the ground that the tumor may exist for years before it thus manifests itself. Also, as in a case reported by him, growth may be deep into the subcutaneous tissues, without any discoloration of the skin.

A glomus tumor below the nail bed,

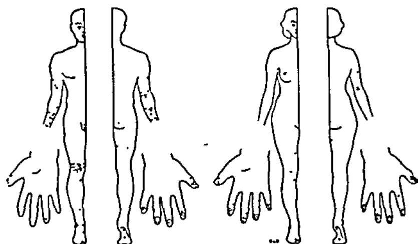


*Figure 301.* Distribution of single glomus tumors in the male and female; composites of 112 reported tumors in men, 111 in women. Each dot represents one nodule. Laterality has not been taken into account (Beaton, L E, and Davis, L Quart Bull Northwestern Univ. M. School, *15*:245, 1941)



*Figure 302.* Typical subungual glomus tumor beneath the nail of the little finger (infra-red photograph). (Love, J G: Proc. Staff Meet., Mayo Clin., *19*:113, 1944)

the hydatidiform mole, the wild-looking cells of which may infiltrate the uterine wall but which is distinguished from chorio-epithelioma because it does not metastasize.

The clinical picture of solid endothelioma is not characteristic and biopsy is necessary for diagnosis. Surgical removal is completely effective if the growth is limited to the skin It is equally effective in the deeper tissues if it can be accomplished, but if infiltration is extensive and the tumor is located in the vicinity of important structures, this is not always possible. Conservatism must be practiced in such cases. Interstitial irradiation is recommended, in low dosages ($\frac{1}{10}$ millicurie per cubic centimeter of bulk) unless there is reason to use larger dosages.

***Hemangiosarcoma.*** Hemangiosarcomas can be explained on an embryologic basis. In the embryo the endothelial cells first form solid cords and islands. Then the lumen appears, and finally the isolated structures unite to form continuous tubes. If the structures in some areas fail to unite and remain segregated as they continue to grow, they form hemangiomas, which later may or may not unite with normal vessels. These tumors may remain as simple capillary tubes consisting of endothelial lining surrounded by a delicate reticulin framework, or they may contain other cells normally associated with blood vessels such as smooth muscle and pericytes and possibly other cells of mesenchymal origin. According to Stout, two criteria are essential for diagnosis of this malignant tumor: (1) formation of atypical endothelial cells in greater numbers than would be required to line vessels with simple endothelial membrane, and (2) formation of vascular tubes with a delicate framework of reticulin fibers and with a pronounced tendency for the lumens to anastomose When he analyzed the literature of malignant vascular tumors in 1943, he found reports of 118 but would not accept 41, more than a third of the total number, because they did not meet these criteria of malignancy.

Hemangiosarcomas spread and infiltrate, their progress suggesting the growth of capillaries into granulation tissue. Often they are multiple. They tend to bleed, either externally or into themselves. Often they occur over a widespread area, as if they were caused by some systemic disturbance of the vascular system, such as von Recklinghausen's disease (neurofibromatosis).

In 20 cases of angiosarcoma (hemangiosarcoma by the nomenclature we propose) observed by McCarthy and Pack at Memorial Hospital over a 10-year period, the sex incidence was almost equal. Fourteen of the 20 cases occurred before the age of 40 years, most of them between the ages of 10 and 30 years. Fourteen patients were Jewish and 1 Italian. The anatomic distribution was diverse but 7 of the cases occurred on the lower extremities and 4 on the upper. In some instances trauma was a factor.

Hemangiosarcoma usually appears as a firm, bulky, solitary tumor located deep in soft tissue. Hemorrhagic, cystlike cavities, necrosis and mucoid degeneration are characteristic.

The clinical course depends upon the location of the lesion, its type and its aggressiveness. Tendons and bones are resistant, but muscles, fat and veins are readily invaded. In McCarthy and Pack's series, tumors of the extremities were characterized by rapid growth, bulky tumefaction, pain and edema. In the nasal cavity and sinuses the clinical picture included epistaxis, headache, nasal obstruction with gradual swelling, displacement of the eye on the affected side, and bony destruction. In the breast, growth was rapid and aggressive. In 3 cases the clinical and histologic evidence indicated that benign angiomas can and do progress to angiosarcoma after irradiation therapy.

### Tumors Originating in the Neuro-myo-arterial Capillary Shunt

The neuro-myo-arterial glomus is a normal structure found in the fingers, nail beds, toes, feet, and probably other parts of the body. It is a peculiar arteriovenous anastomosis in which the blood vessel, which is usually twisting or S-shaped and is thin-walled, is surrounded

entire nail is removed by splitting it from the distal edge to the base. The tumor is then completely excised with a scalpel, care being taken to include tissue well beyond the limits of the lesion.

*Hemangiopericytoma.* The tumor which Stout and Murray[19] first described in 1942 as a hemangiopericytoma features, as they expressed it, Zimmermann's pericytes. By tissue culture they were able to show that the epithelioid cell of the glomus tumor is derived from Zimmermann's pericyte, a contractile cell which surrounds the capillaries with its long processes and seems to change the caliber of their lumens. It is Zimmermann's theory that the pericyte is a modified smooth muscle cell.

A glomus tumor, according to Stout and Murray, is a complex organoid neoplasm with many axis cylinders, a sort of caricature of the normal neuro-myoarterial glomus. The tumor that they called a hemangiopericytoma is, in contrast, composed of capillary blood vessels surrounded by one or more layers of round cells. The organoid encapsulated character of the glomus tumor is lacking. The hemangiopericytoma differs from a hemangioma because of the presence of rounded perivascular cells (pericytes). It also differs from a hemangio-endothelioma (hemangiosarcoma) because the endothelium is normal and shows no infiltrative properties.

In the 9 cases of hemangiopericytoma which Stout and Murray reported, tendencies toward infiltration were evident in some cases, and one patient died of apparent metastases.

### Multiple Vascular Tumors Arising in Systemic Deficiencies

Development of multiple hemangiomatous lesions in certain areas of the body or throughout the body suggests the operation of some systemic factor which is often hard to explain. Certain symptom-complexes have been recognized as entities and have been given eponyms.

***Benign Congenital Hemangiomatosis.*** *Rendu-Osler-Weber's disease* (hereditary hemorrhagic telangiectasia) was defined by Quick[20] as an inherited maldevelopment of the minute blood vessels in localized areas which predisposes them to injury and serious bleeding. The disease is transmitted as a simple dominant which affects both sexes. It appears as tiny reddish or purplish telangiectatic dots which may be punctate, rough, macular or sessile. These spots are most often found in the skin and mucous membrane of the oral and nasal cavities. Although they are congenital, for some unexplained reason they often do not become troublesome until middle age. Epistaxis and bleeding from the upper respiratory passages are characteristic; the bleeding is the result of faulty development of the involved blood vessels. Differentiation from hemophilia and thrombocytopenia depends upon demonstration of a normal coagulating mechanism.

*Sturge-Weber's disease* (encephalotrigeminal angiomatosis) is characterized by the unilateral involvement of the cerebrum and face. The syndrome is made up of four components: (1) the facial hemangioma, a port-wine stain usually limited to the distribution of the trigeminal nerve, particularly the ophthalmic division; (2) cerebral manifestations; (3) ocular disturbances, such as infantile glaucoma, unilateral exophthalmos, ocular atrophy, nystagmus, hemianopsia and ocular palsies; (4) characteristic roentgenologic findings in the skull.

*Lindau-von Hippel's disease* is a hereditary disease in which multiple hemangiomas of the brain, most often the cerebellum, and the retina occur simultaneously.

*Systemic hemangiomatosis* (hemangioma unius lateralis) is a congenital arteriovenous aneurysmal anomaly which may involve an entire extremity or some portion of the head or trunk. Multiple arteriovenous communications exist. There is a tendency toward hypertrophy or overgrowth of the affected part, constantly associated with hypertonicity of the sympathetic system manifested by hyperhidrosis and vasoconstriction in the part involved. The sweating may be so profuse as to be a source of constant embarrassment. The vasoconstriction may

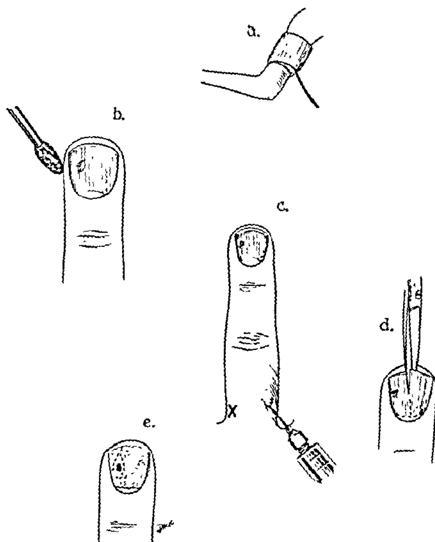



*Figure 303* Technique of removal of subungual glomus. *a*, Blood pressure cuff applied to render field bloodless *b*, Location of the glomus is marked with gentian violet. *c*, All four digital nerves are blocked from the dorsal surface of the finger. *d*, Nail is split and excised *e*, Glomus is excised.

which is a rather frequent location, appears as a small purplish area (Fig. 302). The nail may be somewhat deformed distally and the distal phalanx may show some atrophy on roentgenologic examination. Lesions in other locations tend to be larger than subungual lesions and are freely movable.

The outstanding clinical characteristic of a glomus tumor is pain, which is paroxysmal and may be spontaneous or provoked. It resembles tic douloureux in its severity. Vasomotor disturbances are common. In Kolodny's case there was increased sweating on the palmar surfaces of the fingers.

Treatment is by excision, which practically always gives excellent results. In subungual lesions the entire nail should be removed; this is simpler than to try to remove the tumor through an opening in the nail. Removal of a subungual glomus (Fig. 303) may be carried out in the outpatient department with use of a local anesthetic, such as a 1 per cent solution of procaine or lidocaine, under sterile precautions. The technique is illustrated in Figure 303 A blood pressure cuff is used on the arm to obtain a bloodless field after the extremity has been elevated to drain the blood from it. Since the color of the tumor is usually dependent on the blood it contains, it is wise to mark the area of the tumor carefully by some means, such as the application of gentian violet, in order to insure its complete removal. The four digital nerves are blocked from the dorsal surface of the finger, and after satisfactory anesthetization has been obtained, the

coma 16 of the 36 patients were Jewish and 14 were Italian.

The disease, which is a true, but atypical, sarcoma, begins as a single, bluish red macule, which in 87 per cent of the cases in this series was on the lower (26 cases) or upper (5 cases) extremity, usually on the hands or feet (Figs. 301 and 305). In the hemangiosarcoma series 11 of the 20 tumors involved the extremities. In 3 cases the primary lesions were on the penis and in 2 others, both in women, the lymph nodes were affected first. The authors speculated that occupations that require long standing may play some part in the pathogenesis, in the same way that lymphedema may be a factor in the genesis of lymphangiosarcomas.

No bacterial or viral agent has been identified in Kaposi's sarcoma. That it is caused by a systemic carcinogen is no more than a plausible supposition at this time. Sex hormones may play some role.

There are three pathologic stages, the inflammatory stage, which is the initial stage, the granulomatous or nodular stage, and the neoplastic stage, but progress of the disease otherwise is widely varied. In the early macular stage, on histologic examination the vessels of the derma are dilated and surrounded by an infiltration of round and connective tissue cells. Edema and hemorrhage are minimal. Little in the sections suggests the ultimate sarcomatous potentialities of the lesion. In the granulomatous stage the cardinal features are edema, hemorrhage, connective tissue proliferation and growth of endothelial cells to form vessel sinuses resembling hemangiomas. The attempt at new vessel formation, however, is not complete, and red blood cells are able to escape into the tissues, resulting, as McCarthy and Pack expressed it, in the "hemorrhagic stigma which is constant in all phases of Kaposi's sarcoma." In the final, sarcomatous stage the histologic picture is composed of spindle cell sarcoma interspersed with hemangiomatous elements and deeply stained with old blood pigment. The cellular variations may explain the indolence or aggressiveness of the lesion.

As the early macule progresses to the second stage, it suggests malignant melanoma. The original single lesion slowly multiplies, and the multiple lesions coalesce to form plaques. The extremities typically become involved in the so-called stocking or glove distribution and the lesions then spread to the trunk and eventually to the viscera. The extremities become edematous and the lesions ulcerate and bleed, but unless the soles or the penis should be involved, pain is not a feature of the disease. Death may result from cachexia, infection or hemorrhage, which is frequent if the gastrointestinal tract and the lungs are affected. If the initial lesions are in the lymph nodes or the viscera, the disease may progress to a fatal termination without the appearance of cutaneous manifestations at any time. In some cases the course of the disease is prolonged and little tendency to metastasis is observed.

## TUMORS OF THE LYMPH VESSELS

*Lymphangiomas.* It is curious that lymphangiomas should be so uncommon, considering the enormous regenerative capacity of the lymphatic system. They are much less frequent than hemangiomas. There were only 41 in the 1363 blood and lymph tumors reported by Watson and McCarthy[4] from Memorial Hospital. The only other large series reported in the medical literature are the 28 cases recorded by Singleton[21] in 1937 and the 42 recorded from Charity Hospital of Louisiana at New Orleans by Nix[22] in 1954.

These are predominantly tumors of childhood. Almost two-thirds are present at birth and most of the remainder appear in childhood. In 30 of Nix's 42 cases the patients were younger than 15 years of age; 12 of the 15 were less than a year old, and 4 of the 12 were less than a month old. This is typical. The racial incidence is seldom mentioned in the literature, but in Nix's series 29 of the 42 patients were Negroes.

Both the origin and the etiology of



*Figure 304.* Bilateral Kaposi's disease involving lower extremities.

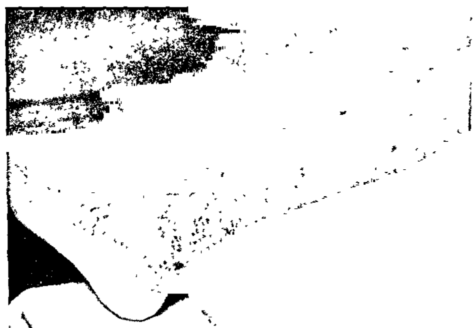


*Figure 305.* Kaposi's disease of extremity

result in dusky discoloration of the part. Treatment of any of these multiple vascular conditions is a major surgical procedure and is often both difficult and disappointing.

***Kaposi's Sarcoma.*** Kaposi's sarcoma is a more common disease than the medical literature would indicate. According to McCarthy and Pack, more than 600 cases had been recorded up to 1950, chiefly as isolated case reports. The following data are derived from their analysis of 36 cases observed at the Memorial Hospital over a recent 10-year period.

In this series, more than three-quarters of the patients were older than 40 years of age, and 33 were males. This distribution is in contrast to that of hemangiosarcoma, in which most of the patients observed by the authors were younger than 40 years of age and the sex distribution was almost equal. The racial incidence, however, was essentially the same in both diseases. In Kaposi's sar-

treatment. Another reason for prompt treatment is that they are radioresistant and irradiation is always the more effective the nearer tissues are to their embryonic state.

At Memorial Hospital the recommended plan of treatment is aspiration, followed by the injection, under strict aseptic precautions, of 1 to 3 cc. of 5 per cent sodium morrhuate solution. If this measure fails, surgical excision is resorted to without delay and is followed by irradiation if, as may often happen, complete surgical removal is anatomically impossible.

*Lymphangiosarcomas.* The development of lymphangiosarcoma in edematous tissues after mastectomy has been reported by Stewart and Treves[23] and by McCarthy and Pack. McCarthy and Pack believed that in many respects this tumor is identical with Kaposi's sarcoma. The



*Figure 307.* Cystic hygroma of right axilla.



*Figure 308* Cystic hygroma of left supraclavicular area and left axilla

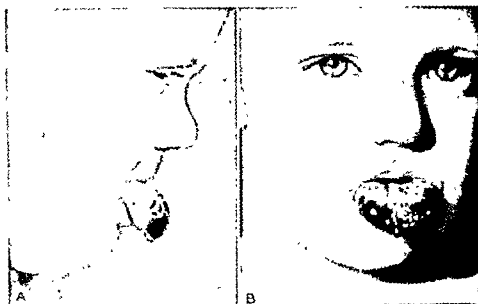



*Figure 306* Macroglossia produced by lymphangioma. *A*, Lateral view; *B*, frontal view, showing superficial excoriation.

lymphangiomas remain to be clarified. They are predominantly parietal tumors and have a special predilection for the head and neck. Thirty-seven of Nix's 42 cases were parietal, 10 occurring in the head and 17 in the neck. The capillary tumors of the tongue (macroglossia) (Fig. 306) and of the lip (macrocheilia) are lymphangiomas.

Lymphangiomas are soft, cystic tumors. In the skin they look like blisters. They contain straw-colored lymphatic fluid and gradually increase in size as the fluid accumulates. A sudden enlargement and bluish coloration are indicative of hemorrhage. Histologic examination shows characteristic flat, endothelium-lined spaces. Hemorrhage, infection and fistulas are possible complications.

The preferred treatment for lymphangioma is surgical, but this plan is not always feasible because of the diffuse nature of the involvement. In extensive lesions, if total excision is impossible, partial excision is often feasible. It should be followed by breaking down the remaining septa and packing the cavity with a sclerosing agent. Venous openings may require ligation. The multiple suture technique and block removal of tissue have also been recommended. Irradiation may be tried, but the results are seldom good, and the dosage, as Watson and McCarthy pointed out, if it is to be at all effective, must be so heavy that scarring is almost inevitable.

Recurrence is frequent with all methods of treatment. In Nix's 42 cases, in which there was no formal attempt at follow-up, there were 9 known recurrences.

*Cystic Hygroma.* Cystic hygroma, which is usually discussed under the heading of lymphangioma, is also an uncommon tumor. There were only 14 in Watson and McCarthy's series of 1363 tumors of the blood and lymph vessels, and up to the time of their report, in 1940, only 225 had been recorded in the world medical literature. Twenty-seven were recorded at the New Orleans Charity Hospital between 1947 and 1951, 21 of these being in Negroes.

Cystic hygromas are usually present at birth and tend to grow rapidly. They appear above the clavicle, usually as soft, puffy masses, though some are of firmer consistency. Occasionally they are seen in the axilla (Figs. 307 and 308). Their multilocular make-up may give the impression of lobulation. They can be transilluminated. Diagnosis is not always simple. In a personally observed case a tumor which had all the characteristics of a cystic hygroma proved to be a lipoma.

Cystic hygromas, because of their tendency to complications, require prompt

*Part VI*

# Genitourinary System

fact that Stewart and Treves observed 6 cases of lymphangiosarcoma in a relatively short time suggests that it may be more common than the limited reports in the literature would indicate. They speculated on a common systemic carcinogenic factor responsible not only for this tumor but for the prior mammary carcinoma.

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*Figure 309.* Technique of circumcision.

contact. Such injuries will result in considerable bleeding from the frenular artery. This requires suture with use of a local anesthetic.

*"Fracture" of the penile shaft* (Fig. 310) may occur during intercourse or as a result of an external blow, in which cases Buck's fascia is torn and a large hematoma develops in the deeper tissues along the shaft. This produces a tense, painful mass as well as distortion of the shaft and, in extreme cases, partial or complete retention of urine from pressure on the urethra. At first, conservative management, consisting of rest and cold applications, should be tried. An indwelling urethral catheter may be required temporarily if urinary retention is complete. In some instances the blood



*Figure 310.* "Fracture" of penile shaft (Buck's fascia).

Chapter 21

# Male Genitourinary Organs

By W. E. Kittredge

## PENIS

### Deformities

***Congenital phimosis*** with narrowing of the prepucial opening is extremely common, and if neglected, predisposes to a variety of lesions involving the glans and undersurface of the foreskin. These include carcinoma of the penis, which has virtually never been seen in patients circumcised in infancy, chancre, chancroid and varying degrees of balanoposthitis. This emphasizes the well recognized fact that circumcision should be done in all male infants except in unusual circumstances. An added advantage of early circumcision is that it may be done at any time during the first several weeks of life without the use of an anesthetic.

*Technique of Circumcision.* In boys between the ages of six weeks and late adolescence, a general anesthetic is required for circumcision. However, the grown child has both a sufficiently large penis to provide the necessary room for local anesthetization at the base and the mental poise to submit to a minor surgical procedure while awake without becoming unduly apprehensive. This age within the second decade of life will vary with the individual. When a local anesthetic is used, anesthetization is accomplished by making a complete wheal surrounding the circumference of the penis near its base in the skin and subcutaneous tissues, followed by deep injections of the anesthetic agent to the left and right of the midline of the dorsum near the base in order to block the two nerves coursing out to the distal end of the organ. A dorsal slit should then be made, after which the foreskin is cut around to the frenum on both sides, care being taken to leave a sufficient cuff of mucosa just below the corona of the glans penis to provide enough redundant skin to permit future erections without undue tension on the skin (Fig. 309). All bleeding points should be carefully secured and the skin and mucosa approximated by interrupted catgut sutures. Most patients can continue to be ambulatory after this procedure. Stilbestrol in doses of 5 mg. a day and ice-cold water baths during the first two or three postoperative days have been employed with some success to prevent or relieve painful erections which often otherwise occur during the early healing period. A petrolatum gauze dressing covered by a bandage should be used and changed frequently until healing occurs.

***Chordee*** (see Hypospadias, p. 424).

### Injuries

***Minor contusions and abrasions*** of the skin of the penile shaft occur frequently as a result of trauma. These should be kept clean with appropriate dressings in order to prevent infection. Occasionally, the skin of the penile shaft is denuded to a greater or lesser degree as the result of external violence. In extreme cases skin grafting may be required. However, if the denuded area is not too large, a remarkable degree of spontaneous healing can occur because of the abundance of loose redundant skin covering this organ. Therefore, conservative management may be all that is necessary.

***Injury to the frenum*** may result from external violence, usually during sexual

occur sometimes as a manifestation of balanoposthitis. It can also occur as a result of ulcerative lesions of the undersurface of the foreskin or glans penis, which in turn produce sufficient irritation of the foreskin to promote intense swelling and congestion. With chemotherapy, hot soaks and local irrigations, swelling will subside. The underlying lesion can then be exposed so that proper local treatment may be employed. After healing, circumcision should be done to prevent recurrence.

*Paraphimosis* is characterized by congestion and edema of the retracted foreskin so that its caliber is reduced to such an extent that it is difficult or impossible to reduce it beyond the corona of the glans penis. A vicious cycle occurs as the venous return from the distal end of the penis is impeded, and tightening and swelling continue to increase. If it is not reducible by manual manipulation of the glans through the foreskin (Fig. 311) or by hot soaks, a dorsal slit will be necessary as an emergency measure to relieve the tension and prevent gangrene of either the foreskin or glans, or both. Local injections of hyaluronidase directly into the edematous foreskin have been used with some success in relieving the edema.

*Venereal Lesions. Chancre* develops usually from three to four weeks after sexual exposure and most frequently on the penis. It appears as a single, hard, clean, punched-out, painless ulcer. If inguinal adenitis is also present, the nodes are discrete, movable and nontender. Chancre resists all forms of local therapy. It is diagnosed by darkfield microscopic examination of scrapings from the lesion taken after all forms of local therapy (such as powders or ointments) have been discontinued for at least 24 hours. The *Treponema pallidum* may then be easily recognized. One should not wait for development of a positive serologic reaction in the diagnosis of this lesion, as this may be somewhat delayed.

*Chancroid* appears within a few days after sexual exposure and is caused by the bacillus of Ducrey, a facultative anaerobe. The lesions may be multiple and are soft, painful, irregular in outline with undermined edges and have a foul discharge. There may be an asso-

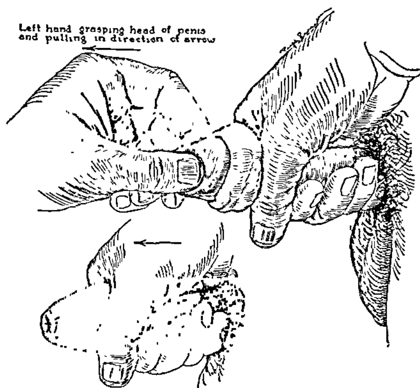



*Figure 311.* Method of reduction of paraphimosis. (After Steinmann from Hinman, F.: Principles and Practice of Urology. Philadelphia, W. B. Saunders Co)

will be almost completely reabsorbed so that eventually only a small, fibrotic, asymptomatic mass remains. Occasionally, on the other hand, the hematoma will have to be excised surgically should it remain of large size and become organized

***Dislocation of the penis*** may result from external trauma. The penis is displaced beneath the skin of the scrotum, lower part of the abdomen or symphysis pubis. This is recognized by failure to identify the penis on examination and requires prompt mechanical restoration of the penis to its normal position in order to allow normal urination and to prevent extravasation of urine within the tissues where the displacement occurred.

***Constricting bands*** or rings of various types are sometimes deliberately placed around the penile shaft near the base in an effort to control urinary incontinence or enuresis, sometimes for purposes of masturbation or to improve sexual power and erection. Inevitably this produces congestion of the distal end of the organ because of interference with venous return, and this in turn causes considerable tightening of the band so that it becomes impossible to remove it. This necessitates prompt cutting and removal of the band in order to prevent necrosis and gangrene.

***Plastic induration of the penis*** (Peyronie's disease) is a not infrequent lesion consisting in formation of a longitudinal fibrous plaque in one of the corpora. It is thought by some to be due to an old localized infection resulting in circumscribed fibrosis. Others believe that at times the lesion is the end result of trauma wherein localized extravasation of blood in one of the corpora cavernosa later becomes organized, producing the characteristic hard, fibrous mass. It is of insidious onset and makes itself known by causing, on erection of the penis, curvature to the side on which the lesion exists, with or without pain Some lesions are of such minor degree that they never cause the patient any real concern. Others are progressive and gradually produce extreme deformity and pain. The condition is easily recognizable by the history and by palpation of a fibrous mass.

Several methods of treatment are in use today for those whose symptoms justify treatment, including daily administration of large doses of vitamin E for at least three months in the hope that it will cause some dissolution of the fibrous tissue, local injections of cortisone directly into the plaque, and irradiation of the lesion by roentgen ray or radium. It should be emphasized, however, that irradiation involves the risk of dangerous reaction and should be tried only when thoroughly justified, and then only by one well trained in irradiation therapy. Surgical excision of the fibrous mass is still advocated by some but is not generally popular.

### Infections

***Balanoposthitis*** represents an infection of the surface of the glans penis and the undersurface of a long, redundant foreskin. In some instances it is secondary to gonorrheal urethritis, and in these cases it is due not to actual invasion of this area by the gonococcus but to irritation from the liberated endotoxin of the disintegrated organisms in the gonorrheal discharge. It is characterized by intense redness, congestion and swelling of the glans penis and the undersurface of the foreskin Prompt relief may be obtained by control of the gonorrheal discharge, soothing irrigations of the affected areas and hot soaks.

In other instances balanoposthitis will occur as an independent lesion due to nonspecific organisms. Poor hygiene of the affected area because of a nonretractable foreskin or any factor predisposing to lowered resistance may precipitate its development. In some instances the lesion may assume a gangrenous form as a result of infection with a bacillus or a spirochete.

Treatment of the acute infection consists in cleanliness, local irrigations, hot soaks and chemotherapy. *Eventually*, circumcision must be done to provide good local hygiene in order to prevent recurrence.

***Phimosis.*** Inflammatory phimosis will

condylomata, care being exercised to avoid spread of the liquid to the circumjacent normal tissue. If this does occur, the liquid should be immediately wiped off with a cotton-tipped applicator. The medicine should be allowed to remain on 24 hours, and is then washed off with soap and water. The minimal effective time for leaving the drug on is 8 hours, although 12 to 24 hours is the optimal duration for therapeutic action. If applications are made beneath a foreskin, balanitis and unretractable foreskin always occur. This may cause some concern, but the swelling will subside in 24 to 48 hours. In the perianal region or groin, only single warts or small groups should be treated at one time, as the inflammation in the circumjacent normal tissue is likely to cause discomfort. Also, if the drug has been left in the perianal region for 12 to 24 hours, sitz baths should be employed. In the occasional or persistent case the lesions should be surgically excised with use of a local anesthetic.

*Other Penile Tumors.* Persistent proliferative or ulcerative lesions of the penis should be suspected of being malignant, and biopsy with use of a local anesthetic performed. Malignant lesions of the penis and external urethra are treated by partial amputation. Sebaceous cysts, and cysts of the frenum or median raphe, occasionally occur and may require excision. Benign hemangioma of the glans penis may occasionally be encountered. Leukoplakia of the glans requires careful observation because of the possibility of malignant change.



*Figure 313.* Condylomata acuminata.

### Miscellaneous

*Priapism* consists of a prolonged penile erection, sometimes painful, occurring spontaneously and without erotic associations. It may occur at any age. It is due to interference with the venous return from the penile shaft, which in turn may be caused by a variety of factors. Because it is a frequent symptom of leukemia and occasionally sickle cell anemia, appropriate blood studies should be promptly carried out in every case. Other instances are of nervous origin, and usually a spinal anesthetic in an adult or a general anesthetic in a child will relieve the erection in such cases. In still other instances, inflammatory swellings or hematomas due to trauma involving the perineum may cause local obstruction to the venous return. This can readily be recognized from the history and examination of the perineum, and if resolution fails to occur after some days of conservative therapy, incision and drainage of the perineum will be necessary. If all obvious precipitating causes, including neurogenic, obstructive and hematologic, have been excluded, the first step in treatment should be administration of an anesthetic, preferably spinal except in children. Should this fail, aspiration of the blood from the corpora through a 15 gauge needle introduced into the shaft after the patient has been anesthetized will provide relief. More recently, curare has been used with some success.

## URETHRA

### Congenital Deformities

*Congenital Narrowing of the Urethral Meatus.* Pinpoint meatus occurs occasionally and may or may not cause recognizable symptoms in early life. A pinpoint meatus in the newborn can usually be corrected, temporarily at least, by the



*Figure 312.* Granuloma inguinale (inguinal region).

ciated acute inflammatory inguinal adenitis. The infection responds well to appropriate antibiotic therapy. It must be remembered that even if the lesion is typically chancroidal in appearance, it may be a mixed sore with an underlying chancre, which makes a darkfield examination of scrapings from all such sores mandatory to rule out the diagnosis of syphilis. Likewise, serology should be routine in all cases.

*Granuloma inguinale,* a raised, irregular, granular lesion resulting from sexual contact, is frequently seen on the genitalia (Fig. 312). A Wright stain of scrapings from the lesion will usually show typical Donovan bodies. This lesion also responds favorably to antibiotic therapy.

*Lymphopathia Venereum.* The primary lesion of this disease is an evanescent vesicle occurring on the penis after sexual exposure. It heals promptly without a scar and is seldom recognized by the patient. The disease becomes evident some weeks later by development of acute inflammatory inguinal adenitis. The diagnosis is made by the intradermal Frei test. Treatment consists of administration of antibiotics.

*Fordyce's disease* consists in multiple vesicular lesions involving the circumference of the corona of the glans penis. It is due to chronic irritative factors and is of no special importance but may cause the patient some concern. It may be controlled by one or more applications of a 10 per cent solution of silver nitrate on a cotton applicator to the involved area.

### Cutaneous Diseases

*Herpes Progenitalis.* Herpes of the penis is similar to herpes elsewhere and has the same etiologic background. A group of vesicles will appear on the prepuce or penile shaft, and will be limited to one side. The involved area itches and burns. The vesicles soon rupture, leaving small ulcers which may become secondarily infected. They heal promptly, unless infected. The only treatment required is protection from secondary infection by dryness and cleanliness.

Most of the recognized cutaneous diseases may occur on the genitalia and differ in no way from the same diseases occurring on other parts of the body.

### Tumors

*Condylomata acuminata* (venereal warts [see condylomata of the anal region, p. 316]) are actually multiple papillomas involving the skin of the genitalia and grossly resemble warts (Fig. 313). Lack of cleanliness is a predisposing cause. When these lesions appear on the undersurface of the foreskin or on the glans penis, circumcision is mandatory to prevent recurrence. There is some evidence that they may be transmissible by sexual contact, which in turn raises the possibility that they may be due to a virus. They are recognizable on sight.

Treatment, in addition to attention to cleanliness, consists in local application of 20 per cent podophyllin powder in tincture of benzoin. The technique[1] is as follows: With an applicator the liquid is applied to the surface and sides of the

absence of the roof of the urethra, requires major plastic surgical correction.

INJURIES OF THE EXTERNAL URETHRA[2, 3]

The external urethra may be injured by external or internal violence. External injury is caused by a blow to the penis or perineum, the latter usually as a result of a kick or a fall astride some object. Internal violence may be caused by improper passage of a rigid instrument through the urethra. Occasionally, the injudicious use of excessively strong chemicals for irrigation of the anterior urethra will produce varying degrees of chemical trauma to the urethra.

*Simple lacerations* of the external urethra without any break in the continuity will be evident only by a continuous slow oozing of blood from the external urethral meatus. Gentle passage of a small catheter to the bladder will confirm the fact that the urethra is intact and that the urine from the bladder itself is free of blood. In these cases there is no extravasation of urine since the urethra is intact. There is no necessity for leaving a catheter indwelling except in rare instances in which there is sufficient bleeding from the meatus to require an indwelling catheter for purposes of compression in order to stop the bleeding. The fact that the bleeding in these cases is continuous and not dependent upon the act of urination is proof that the injury lies external to the external urethral sphincter.

*Partial Tears of the Urethra.* Patients with such an injury may continue to urinate in an apparently normal manner but leakage of urine into the tissues outside the urethra occurs and leads to swelling and the superficial signs of inflammation, first of the perineum and penile shaft and later of the scrotum or even the lower abdominal wall in neglected cases. The areas that can be expected to be involved can be anticipated by the fact that the defect is anterior to the triangular ligament and the extravasated urine, therefore, will follow the fascial planes, as shown in Figure 316. The local evidences of extravasation are invariably associated with the various systemic symptoms of infection and toxemia and require prompt drainage of the involved areas as well as diversion of the urinary stream. The latter may sometimes be accomplished merely by use of an indwelling catheter in patients with relatively small incomplete tears in whom a catheter can still be introduced into the bladder, or suprapubic cystotomy may be necessary. Infection should be combated by chemotherapy, and later hot sitz baths should be taken to promote healing. Patients in whom the anterior urethra has been completely severed will be unable to void, and in attempting to do so, will force urine into the soft tissues. Attempts to catheterize these patients meet with obstruction at the point of injury. This immediately indicates the necessity for a major surgical procedure to divert the urinary stream, drain the extravasated areas, and re-establish the continuity of the urethra under direct vision. Likewise, treatment of an injury to the membranous or deep urethra is invariably a major surgical procedure.

*Urethral fistulas* may occur along the penile urethra as a result of external or internal trauma with perforation of the urethra, or after external rupture of a periurethral abscess. Most will eventually close spontaneously within a period of six months. If this does not occur, the fistulous tract must be dissected out and

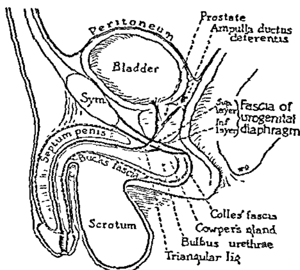



*Figure 316.* Diagrammatic sketch showing the fascial planes which determine the course of phlegmonous infiltration.

introduction of a pointed instrument, such as a hemostat, followed by spreading of the jaws of the instrument. In later life when it may produce some reduction in the size and force of the stream of urine, predispose to chronic urethritis or interfere with passage of an instrument through the urethra, the urethral meatus should be cut a little to one side of the midline on its ventral aspect, with use of a local anesthetic. It is helpful first to crush with a clamp the area intended for incision, in order to prevent the bleeding which will otherwise follow. It is necessary to suture the urethral mucosa to the glans on each side of the incision and to put a small strip of petrolatum gauze between the edges in order to prevent the meatus from healing in its original form.

*Congenital atresia of the urethra* or portions of it rarely occurs; it may cause death from renal failure *in utero.* If, however, the child is born alive, it is necessary to establish a lumen through the urethra, if possible, by gentle passage of a small steel sound in order to perforate the obstructive lesion so that a small catheter may be introduced into the bladder. The catheter should be left in place for a time in order to allow sufficient dilatation of the urethra, as well as drainage for the urine until normal urination can be established. If instrumentation of the urethra is not successful, external urethrotomy or suprapubic cystostomy must be promptly done in order to establish urinary drainage. At a later date a patent urethral canal should be constructed, if possible.



*Figure 314.* Hypospadias. Pointer indicates location of external urethral orifice.



*Figure 315.* Epispadias.

***Hypospadias*** is a congenital deformity in which the urethra opens on the ventral surface of the penis or in the perineum (Fig. 314). The anomaly may be classified into first, second and third degrees, depending upon the location of the urethral meatus. In first degree hypospadias, the urethral orifice is just behind the glans penis. Such patients require nothing more than reassurance that in married life they will ejaculate normally into the vaginal vault, thereby offering no handicap to conception. In second degree hypospadias, in which the urethral opening is somewhere along the penile shaft back to and including the penoscrotal junction, and in third degree hypospadias where there is a bifid scrotum with a perineal urethral opening, a major plastic procedure is required. These patients also have a constricting fibrous deformity of the penile shaft known as chordee, which produces ventral curvature of the penis that requires plastic correction prior to operation on the hypospadias itself.

***Epispadias*** (Fig. 315), or congenital

it will sometimes be impossible to force even the smallest follower through the stricture. In such instances, when only a filiform has been successfully passed, it should be tied in place and left in, as it will not only soften and dilate the stricture to some extent but will also serve as a wick, permitting a considerable amount of urine gradually to flow out alongside the filiform, thus decompressing the bladder. One or two days later, it will usually be possible to pass a metal follower, as the stricture will have softened to a remarkable degree.

In those cases which will not admit a filiform, even after patient and repeated efforts with multiple filiforms introduced into the urethra simultaneously down to the stricture, suprapubic cystotomy will be necessary to relieve the urinary retention. In such a situation, one takes advantage of the fact that the patient is anesthetized and the bladder open, and retrograde dilation of the stricture is carried out by the introduction of two sounds, one from the external urethra and one through the bladder and out until the two are forced to meet. This creates a channel, after which a catheter can be introduced and left indwelling until the urethra heals.

In the average stricture, which will admit a sound with or without a filiform guide attached, a sound is chosen which barely lodges in the initial diameter of the stricture and it is carefully and gently introduced into the bladder. This may be followed by introduction of one or more sounds of additional size, but it is a safe rule never to pass more than two sounds at one sitting. This minimizes the risk of urethral reaction, which is sometimes quite sudden and intense and may be attended by chills, fever and prostration. It is usually adequate to dilate a stricture to a size 24 French maximum, as this will provide a normal stream and no obstruction. It will always be necessary, however, to keep the stricture open by periodic future dilations, usually for the rest of the patient's life. Since strictures will contract at varying rates of speed in different individuals, it is necessary to determine by trial the maximum

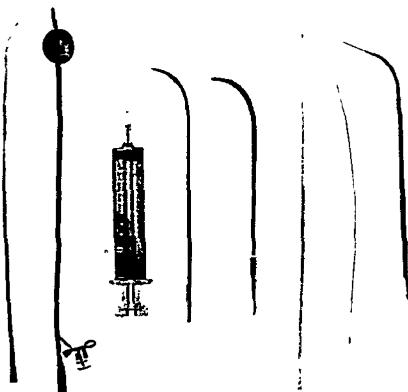


*Figure 317.* Left to right: Coudé catheter, balloon catheter with bag inflated, two ounce aspirating syringe, curved metal catheter, Van Buren sound, bougie, filiform, Le Fort sound with filiform attached

the urethral defect closed. Urethral fistulas occurring in the perineum usually result from chronic infection and urethral stricture, resulting in subacute perforation of the urethra followed by perineal abscess and, later, one or more openings in the skin with formation of a sinus tract from the urethra to the perineum. Usually dilation of the stricture followed by use of an indwelling catheter will permit spontaneous closure of these fistulas.

*Chemical injury* to the anterior urethra will be evidenced by bleeding, intense pain along the urethra and later a profuse discharge, which on microscopic study, will usually show pus cells but few, if any, organisms. The immediate treatment should consist of hot sitz baths and soothing irrigations of the anterior urethra with potassium permanganate (1:8000) or some similar solution. In severe cases pronounced inflammatory stenosis of the involved portion of the urethra will follow, requiring repeated dilations at close intervals until the inflammatory urethritis and periurethritis have completely resolved.

*Stricture of the urethra* may be congenital or acquired. Acquired strictures may be of traumatic or inflammatory origin. Traumatic strictures may be the result of external violence to some portion of the urethra or may follow the improper passage of a rigid or sharp instrument through the urethra. Inflammatory strictures may be infectious or chemical in origin. Those of chemical origin are due to the introduction of caustic chemicals into the urethra and usually result in considerable inflammation of the first portion of the urethra, followed by deep scarring. Infectious strictures are usually of gonorrheal origin and are most frequently seen in the bulbous portion of the urethra following chronic neglected cases of gonorrhea. Strictures may be single or multiple, of small or large caliber, wide or narrow, and straight or tortuous. All acquired strictures result from periurethritis or trauma, with resultant encirclement of the urethra by fibrous tissue which is elastic and tends to contract continually.

The chief manifestation of stricture is reduction in the size and force of the urinary stream, with or without frequency and discomfort on urination. Some patients will have a chronic, nonspecific urethral discharge, which is the result of infection behind the stricture. Perineal urethrocutaneous fistulas following neglected strictures have already been discussed. Calculi may form in the urethra behind a stricture, as the result of infection and obstruction with an accumulation of stagnant, infected urine in this area. Pathologic changes involving the bladder and upper urinary tract, which include stones, infection and dilatation of the upper urinary tract with resultant impairment of renal function, can occur in long-standing neglected cases owing to back pressure from chronic partial urinary obstruction. The diagnosis of stricture of the urethra is made when attempts to pass an instrument through the urethra meet with obstruction at some given point. In the normal adult, a No. 24 French sound (Fig. 317) should be passed without noticeable resistance except the customary hang which occurs at the external urethral sphincter (Fig. 318). In children a proportionately smaller instrument must be used for diagnostic purposes.

The treatment of strictures consists primarily in passage of rigid or semirigid instruments through the urethra in graded sizes at repeated intervals. In patients with extremely tight strictures it is necessary first to introduce a small flexible filiform through the stricture, after which a steel threaded follower (sound) is screwed onto the filiform and forced through the stricture. The size of the follower depends on the tightness of the stricture. A moderate amount of force can be used in passing such a follower, as the filiform guide insures a normal direction for the sound. In cases of acute retention of urine due to stricture, it is an invaluable aid to have a *hollow metal catheter* which is threaded and can be introduced on a filiform in patients impossible to catheterize, not only to dilate the stricture but also to provide catheterization. In extreme cases,

conservative management including hot soaks and antibiotic therapy, diversion of the urinary stream by suprapubic cystotomy and wide excision of the inflamed areas should be seriously considered to prevent dangerous and perhaps fatal consequences after possible neglected extravasation of urine into the tissues surrounding the urethra. In case of doubt surgical drainage is always advisable, as it is distinctly better in this situation to err on the side of safety.

At times resort may be had to continuous dilation of certain dense and resistant strictures. A soft rubber catheter of the maximum size that can be introduced through the stricture is left in place for 24 to 48 hours, after which the stricture will have softened sufficiently to permit introduction of a larger catheter. This process is repeated at two-day intervals until a maximum of a No. 24 French catheter has been introduced and left in for 48 hours. After this, the stricture will be of maximum caliber and it may then prove much easier to keep it open in the future by repeated dilations with metal sounds.

Internal urethrotomy, with a high frequency cutting wire instrument introduced into the urethra, has been frequently used by some for the purpose of cutting through particularly dense and unyielding strictures in an effort to enlarge the caliber of the urethra. However, in some instances the additional scarring around the urethra resulting from the healing of such a cut often makes the end result as bad as or worse than the original stricture. More recently, open plastic surgical procedures on the more intractable penile urethral strictures have been carried out with considerable success.[4]

Occasionally, when it becomes impossible to maintain an adequate opening through an unusually severe stricture, a perineal urethrostomy for permanent diversion of the urine must be considered.

### Foreign Bodies

Foreign bodies may be found in the penis or scrotum as a result of external violence, such as a gunshot, in which case the situation is readily apparent from the history and clinical findings, and the object should be removed with use of a general anesthetic. More frequently foreign bodies, such as pins, hairpins, chewing gum, thermometers, pencils, bamboo reeds or other rigid objects are deliberately introduced into the urethra for purposes of masturbation or attempted catheterization and either become lodged in the urethra or, more frequently, work their way back into the bladder. Stones may occasionally lodge in the urethra during passage from the bladder. Objects in the pendulous portion of the male urethra or in any portion of the female urethra can usually be removed by grasping them with slender forceps passed into the urethra, which has been previously lubricated. Those entering the bladder cause severe cystitis and usually become encrusted with phosphatic deposits, forming a true vesical calculus. In such patients the history is almost invariably misleading, as the patient will not readily admit the act. These foreign bodies are usually found accidentally in the course of routine urologic investigation, including cystoscopy and roentgenography, to determine the etiology of severe cystitis. Such objects may be removed either by transurethral cystoscopic manipulation with use of an anesthetic or by open suprapubic cystotomy.

### Infections

*Gonorrheal urethritis* is manifested by a thick, yellowish urethral discharge associated with redness and swelling of the external meatus and burning on urination. There is almost always a recent history of sexual exposure. The diagnosis is made by microscopic examination of a smear stained with the Gram stain, showing the typical intracellular gram-negative diplococci. Treatment consists in administration of one of the currently recommended antibiotics.

*Nonspecific urethritis* appears as a thin, watery, bluish white urethral discharge without inflammation of the external meatus. There is not necessarily a history of recent sexual exposure. The




*Figure 318.* Passing a sound *A*, Maneuver I; *B*, maneuver II; C. maneuver III.

interval that can be permitted to elapse in any given patient between dilations before significant contraction of the stricture occurs. This may vary from as little as two weeks to as much as a year. In a few instances, strictures of acute inflammatory or chemical origin will completely resolve and eventually require no further attention.

In summary, because of the dangers involved in the improper use of instruments for dilation of strictures, certain rules of management seem worthy of repetition. First, a mild local anesthetic, such as a 4 per cent solution of Metycaine, should be used to provide anesthesia as well as to relax the urethra. Spinal or general anesthesia is not desirable because the patient is unable to feel pain if instrumentation becomes excessively traumatic, with the resultant risk of hemorrhage or extravasation from urethral injury. Next, the instrument should always be passed gently; no sound should ever be forced through a stricture unless it is equipped with a filiform guide preceding it. No blunt-nosed sound of the Van Buren type smaller than a French 18 should ever be introduced in the adult, as the relative size of the tip makes it dangerously sharp for passage in the adult. No more than two sounds should ever be passed at one sitting, and preferably only one. Every patient should be given a short course of a sulfonamide or antibiotic afterwards to prevent postinstrumental reactions. The interval between dilations should never be less than two or three days. Any patient in whom an acute febrile reaction follows dilation of a stricture, or in whom there is any evidence of swelling or inflammation of the penis or scrotum, should be carefully observed for possible extravasation. If the local and systemic reactions do not promptly subside after

this not only decreases the tone and emptying capacity but also deadens the sensation of fullness so that such patients may actually tolerate unbelievably large amounts of urine within the bladder without feeling uncomfortable. In obese patients a distended bladder may not even be palpable. Large amounts of partially retained urine may therefore go unrecognized for long periods of time. This is particularly important in the management of postoperative urinary retention. It must therefore be re-emphasized that the mere facts that the patient has a satisfactory total 24 hour output of urine and does not complain of discomfort on voiding or of a sensation of fullness do not necessarily rule out the possibility of large amounts of partially retained urine. This will be discussed more fully in the section on postoperative urinary retention.

Whereas it is always possible in an instance of suspected partial retention to pass a catheter immediately after the patient has voided in order to measure the amount of retained urine, there are numerous instances in which catheterization is either undesirable or inadvisable because of the risk of infection which might involve the prostate or bladder as a result of catheterization. This risk is multiplied many times in older men with prostatism, and yet it is in this group more than any other that partial urinary retention must be ruled out. Also, in male children it is often undesirable to catheterize the bladder for this purpose if it can be avoided. In such instances a simple, accurate alternate method of demonstrating whether or not a significant degree of urinary retention is present may be employed, by means of the phenolsulfonphthalein renal function test. The phenolphthalein content of the voided specimen is determined at the end of 1 hour and 10 minutes. If it contains as much as 50 per cent of the dye previously administered, it is safe to assume that the bladder has been reasonably well emptied or otherwise a significant part of the dye would have been retained in the retained portion of the total urinary output for the hour. Of course, if the reading is low, it will then be necessary to catheterize the patient to recover the remaining portion of the urine, if any, to add to the original sample in order to get the total reading of the test. This method, however, does at least avoid the necessity of catheterizing those patients in whom the reading is normal. A similar method of determining the presence or absence of significant amounts of residual urine is postvoiding cystography after excretory urography.

*Complete urinary retention* may be due to one cause or a combination of many causes. The commonest cause in the male is some type of mechanical obstruction at the bladder neck. The prostate may produce complete obstruction to urination by any one of four pathologic conditions: benign prostatic hypertrophy, carcinoma of the prostate, contracture of the vesical neck or acute prostatitis. In children, congenital valves in the prostatic urethra, contracture of the vesical neck in either sex or occasionally sarcoma of the prostate may cause complete retention. Other general causes are stricture of the urethra, calculi at the bladder neck or in the urethra, stenosis of the external urethral meatus, rupture of the bladder or urethra, neurogenic disorders of the bladder, carcinoma of the urethra, vesical calculus, rarely a tumor of the bladder growing near the vesical neck, and postoperative urinary retention due to a combination of factors dependent upon the surgical procedure and its sequelae. Every patient with acute urinary retention obviously requires immediate catheterization.

*Technique of Catheterization.* The proper catheter to use for simple catheterization of the male is the Coudé-tipped or prostatic catheter. Made of rubber, it has a baked-in curve at its tip which is tapered down to a small olive-tipped end. The patient should lie on his back with his legs extended. After proper cleansing of the external urethral meatus and draping of a sterile towel over the upper portion of the thighs, the penis is grasped in the left hand with thumb and forefinger embracing the external urethral meatus and the penile

microscopic smear shows pus cells, mucous shreds, epithelial cells and myriad numbers of small nondescript bacilli and cocci. Treatment consists in administration of an appropriate antibiotic and the elimination or treatment of any complicating factor which could serve as the underlying cause of the urethritis. These include chronic nonspecific prostatitis, urethral stricture, infection of the glands of Littre or a long intractable foreskin.

*Littritis* is an infection of one or more of the glands of Littré along the floor of the anterior urethra. It is a frequent concomitant lesion in urethritis but is of special importance in chronic cases in which the small ducts of one or more of the glands become occluded, producing small localized abscesses within the glands. It is recognized by palpation of the glands over a sound in the urethra and is treated either by manual expulsion of the contents of the glands by pressure against the sound, or in persistent cases by cauterization of the glands with silver nitrate fused on a wire through an endoscope.

*Periurethral abscess* may follow severe urethritis, sometimes complicated by stricture, or it may develop after a severe infection of one of the periurethral glands. A localized abscess forms just outside the urethra and gradually works its way to the exterior, appearing at the outer aspect of the penile shaft. Incision of the abscess sometimes results in a temporary urethrocutaneous fistula which will usually close spontaneously.

*Perineal abscesses* are due to cowperitis or obstruction from a stricture located in the bulbous portion of the urethra. Those due to long-standing stricture result later in multiple fistulas of the perineum, usually referred to as the "watering pot" perineum. Treatment of the latter situation consists of dilation of the stricture and re-establishment of normal urinary flow through the urethra, if possible, or if the stricture is impassable or cannot be kept open, a suprapubic cystostomy to divert the urine, after which the fistulas almost invariably heal. When the abscess results from cowperitis, Cowper's gland first becomes infected, with development of a localized abscess which later extends to involve the entire perineum and eventually points in the perineal area. When seen before rupture, it appears as a large mass in the perineum and may exert sufficient pressure to cause partial or complete retention of urine. It may be incised perineally or, if it has already ruptured, there may be a urethrocutaneous fistula, which may or may not require further surgical exploration for additional pockets of infection.

URETHRAL STRICTURES (see p. 426)

URETHRAL FISTULAS (see p. 425)

### MISCELLANEOUS

#### *Retention of Urine*

Urinary retention must be distinguished from urinary suppression. Urinary retention signifies inability to pass urine from the bladder, whereas in suppression the kidneys stop secreting urine and the bladder itself is actually empty. Therefore, in every person who fails to pass urine it is first necessary to confirm the fact that the bladder actually contains urine before the diagnosis of retention is made. At times obstruction at the bladder neck causing retention will also prevent passage of a catheter completely into the bladder. It is therefore necessary, in cases of apparent suppression, to irrigate through the catheter with a measured amount of water and demonstrate that this exact amount can be recovered from the bladder before one concludes that the catheter is actually in the bladder and that no urine is present there.

***Partial Urinary Retention.*** Retention of urine may be partial or complete. The gradual development of an increasing amount of partial retention of urine will often occur so insidiously as to produce few recognizable symptoms. The patient frequently believes that he urinates normally, and he may have a normal total volume output of urine over a period of 24 hours even though a considerable amount is constantly retained within the bladder. In such instances the bladder is gradually stretched to an abnormal capacity. The muscle wall is thinned out;

turbances to the bladder musculature as well as retrodisplacement of the bladder itself and possibly also some resulting distortion of the prostatic urethra.

The possibility of unrecognized partial retention in the patient whose total urinary output in 24 hours is normal and who does not necessarily complain of overdistention or an abnormal desire to urinate must be borne in mind. Partial urinary retention should be immediately suspected in all patients with abnormally frequent urination, pseudo or overflow incontinence, or precipitate urgency that amounts to incontinence. Such patients should be immediately catheterized and if an appreciable amount of urine is obtained, the catheter should be left indwelling. A safe rule is to leave the catheter indwelling in any patient with more than 100 cc. of retained urine immediately after voiding. Once the catheter is left indwelling, it should be allowed to remain in place for a minimum of 48 to 72 hours in order to allow the patient to recover from the aftereffects of the operation and to permit the edema and congestion present at the bladder neck to subside sufficiently to permit normal urination later. Likewise, it should remain open at all times and connected to a bottle by tubing in order to maintain constant relaxation of the bladder musculature so as to preserve its tone. In neglected cases in which the bladder is allowed to overdistend for long periods of time with resultant loss of tone and emptying capacity, as much as one or two weeks in extreme cases of continuous drainage may be necessary to restore normal tone. This again emphasizes the importance of carefully observing patients postoperatively to guard against such an eventuality.

Complete postoperative urinary retention may be anticipated in certain types of operations, and an indwelling catheter can be introduced in the operating room. This includes vaginal plastic procedures and abdominoperineal operations, particularly in men in the prostatic age group. In complete postoperative urinary retention it is permissible to catheterize patients intermittently as often as twice in an effort to get them to void spontaneously. The decision as to when to catheterize in the immediate postoperative period should be governed not so much by the number of hours that have elapsed since operation as by such factors as the patient's fluid intake and fluid loss, blood pressure level, subjective desire to void, and whether or not the bladder can be palpated or percussed above the symphysis pubis. When the bladder can be recognized as having ascended from the true pelvis, this can be considered sufficient proof of fullness to justify catheterization. If after two intermittent catheterizations the patient is still unable to void, it is always best to leave a catheter indwelling, since further efforts at intermittent catheterization will only worsen the contamination, trauma and congestion created in the urethra, prostate and bladder by repeated passage of the catheter.

It must be borne in mind that any patient who wears an indwelling catheter inevitably acquires infection. This infection will involve only the bladder, and the prostate in the male, as long as continuous drainage is maintained to prevent ascending infection of the kidneys. Therefore, the urine that drains through the catheter is always infected but does not cause fever, a fact often of value in the differential diagnosis of otherwise unexplained postoperative fever. This, however, does not hold true once the catheter has been withdrawn, as back pressure resulting from the filling of the bladder and the patient's effort to urinate can sometimes produce ascending pyelonephritis. Because of this possibility it is always wise to start administration of some appropriate urinary antiseptic, such as one of the sulfonamides or antibiotics, usually 24 hours before contemplated withdrawal of the catheter in order to forestall an ascending infection, and to continue it for seven days after removal of the catheter to insure complete sterilization of the urine. Residual prostatitis resulting from an in-

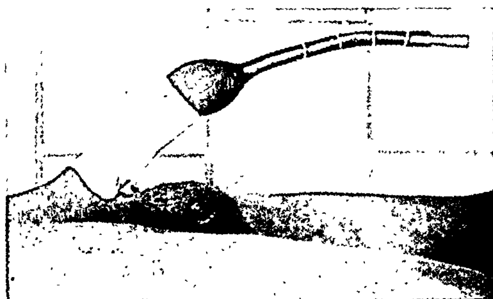


*Figure 319.* Indwelling catheter secured with rubber bridle and adhesive tape.

shaft is pulled up tightly in a vertical direction. The catheter is held in the right hand at its mid-portion in order to preserve complete sterility of the proximal end, which is the only part that will eventually be introduced into the sterile prostatic segment of the urethra and bladder. The curved end of the catheter is introduced into the meatus turned toward the patient's head. When in this position and slowly introduced, the curved end will hug the smooth roof of the urethra all the way to the bladder and thereby avoid hanging in any one of the numerous anatomically normal deviations of the urethral floor which might otherwise arrest progress of the catheter. These include the fossa navicularis, the bulbous portion of the urethra, the external sphincter, the verumontanum and any elevation present at the neck of the bladder.

For simple catheterization a No. 18 catheter is routinely used in the adult. In patients of either sex, when it is contemplated that the catheter will be left indwelling, it is best to use a straight balloon type catheter, also a No. 18, so that the balloon may be inflated after catheterization and the catheter secured in place in this manner. If a Coudé catheter proves the only type that can be introduced even when it is meant to be left indwelling, it can be secured in place by means of a rubber bridle and adhesive securing the catheter to the penile shaft (Fig. 319). In instances of complete retention due to tight strictures it may be necessary at first to introduce a filiform guide through the stricture, on which is screwed a No. 16 French hollow metal catheter which can be forced through the stricture. This, of course, also accomplishes dilatation of the stricture, after which it is usually possible to pass a smaller soft rubber catheter if an indwelling catheter is desired. The previously accepted belief that a greatly overdistended bladder could not be rapidly decompressed has been definitely disproved. It is safe to drain whatever quantity of urine the bladder may contain at the time of catheterization.

*Postoperative urinary retention* merits separate discussion since it is extremely common, affects both sexes at all ages and requires certain rigid rules of management. The causes of postoperative urinary retention include anesthesia, postoperative narcosis, prostration, edema of the bladder neck or urethra after operations involving or close to these areas, certain degrees of neurogenic dysfunction after procedures involving or near the important nerve trunks supplying the bladder muscle and the combination of factors in abdominal perineal surgery including both neurogenic dis-

izes, though there is some additional risk of infection, which can be fulminating and result in considerable loss of tissue including not only parts of the scrotum but also possibly of the testis. In chronic cases in which resolution is incomplete the contained blood clot becomes organized into a firm painless mass which must be removed surgically.

#### Cutaneous Diseases

*Pruritus* of the scrotum is similar to pruritus of the perianal areas and in the absence of some demonstrable infectious organism is usually thought to be neurogenic. Often a source of much distress to the patient, it is persistent and difficult to treat. Local applications of the usual soothing skin ointments will help relieve the itching.

### SPERMATIC CORD

#### Injuries

The extent of such injuries varies from laceration of one or more vessels to complete severance of the spermatic cord. This results in development of a rapidly progressive hematoma within the scrotum with extravasation of the blood onto the abdomen, eventually including the penis and thighs. Surgical exploration is necessary to determine whether conservative suturing of the lacerated areas will be sufficient or whether orchidectomy will be required.

***Torsion of the spermatic cord (testis)*** [5, 6] is usually due to an abnormally long or absent gubernaculum testis, resulting in excess mobility of the testis which is not properly anchored to the scrotum. It is sometimes seen after childbirth and is often erroneously diagnosed as traumatic epididymitis and treated conservatively, with resultant atrophy of the testis later. However, most patients are early adolescents or young adults, as it is usually only a matter of time before this poorly fixed testis will be turned on its axis as the result of some external influence, such as trauma or sudden exertion, with the resultant clinical picture of torsion, due to occlusion of the venous return from the testis in the spermatic cord. It may also occasionally occur in the undescended testis. The onset is sudden, with painful swelling of the testis and epididymis, which on gross inspection resembles acute epididymitis. However, the history of sudden onset will usually suggest torsion. The demonstration of Prehm's sign is frequently of diagnostic value. This is a maneuver in which, with the patient standing, a hand is placed under the scrotum and the scrotum lifted, thereby relieving the weight of the swollen, heavy testis. In cases of torsion, this makes the pain worse because of further twisting of the cord due to the slack produced by lifting. In acute epididymitis, on the other hand, the pain will be somewhat relieved. The treatment of torsion is immediate surgical correction. It is never possible to manipulate a testis externally and untwist it with any hope of obtaining a permanent result. It is vitally important that operation be done immediately, as it is only a matter of hours before obstruction of the venous return through the cord will result in necrosis and gangrene of the testis. At operation, the testis is inspected after being rotated back to its normal axis. If it appears grossly normal, it is then anchored by sutures to the scrotal wall to prevent further occurrence of torsion. If it appears necrotic or gangrenous, it is removed. It is also necessary at operation to expose the opposite testis and anchor it, because it is to be assumed that the same congenital defect exists on the opposite side and could result in later torsion on this side.

#### Infections

***Funiculitis of the cord*** may occur as an independent lesion. It is often precipitated by sudden exertion as an extension of pre-existing prostatitis or vesiculitis, or in association with epididymitis. It can be recognized by pain and swelling of the cord, perhaps with mild systemic symptoms, and can be assumed in most instances to represent extension of infection from the genital tract. It will subside promptly with the use of any of the antibiotics or sulfonamides together with rest and support of the scrotal contents.

dwelling catheter may require a series of prostatic massages for its elimination later.

## SCROTUM

### Injuries

*Abrasions and contusions* of the skin of the scrotum are unimportant and only require attention to cleanliness and protection of the area from infection. Part or even all the scrotum is sometimes destroyed as a result of involvement in machinery or by some other form of external violence. The testes and cords are thus exposed and must be protected by sterile wet dressings. Because of the remarkable regenerative powers of the scrotum, if any appreciable portion of the scrotal skin remains, it will in time completely regenerate and re-envelop the testes. Otherwise, the simplest solution is to transplant the testes to the superficial area of the medial aspect of the corresponding thigh; this permits the scrotal defect to close. Skin grafting could be attempted in an effort to reconstruct the scrotum but this is much more tedious and the results are uncertain because of infection, which is inevitable in this area.

### Infections

***Infectious Gangrene of the Scrotum.*** A specific gangrenous lesion of the skin of the scrotum may sometimes occur; in some ways it may resemble erysipelas. At first simple, acute, inflammatory changes of the scrotum appear. This is soon followed by systemic symptoms and later by necrosis and slough of large areas of the scrotum. After control of the infection by chemotherapy, aided by the natural slough of the necrotic areas, the remaining portions of the scrotum will usually regenerate and provide an almost entirely normal covering for the exposed testicles.

### Tumors

Sebaceous cysts of the skin of the scrotum are similar to those seen elsewhere. Multiple areas of telangiectasis of the scrotum occur, producing highly vascular lesions which sometimes bleed following trauma. The bleeding may be profuse but can be controlled by compression. These patients sometimes require reassurance, both because of the active bleeding and because their location on the genitalia causes apprehension in many patients. Congenital cysts of the median raphe of the scrotum or penis are occasionally seen and should be excised.

*Carcinoma.* Squamous cell carcinoma of the scrotum was once seen frequently in chimney sweepers but in more recent years has been seen in workers with tar, paraffin and mineral oil as well as in mule spinners of cotton mills. Treatment consists of wide excision of the lesion.

***Condylomata Acuminata*** (pp. 316, 422).

***Scrotal hydroceles*** develop by gradual accumulation of fluid between the layers of the tunica vaginalis in the scrotum, and except when some definite irritating factor can be demonstrated, such as a tumor or infection of the cord, epididymis or testis, no known cause has been found. The onset is insidious, and at first the mass is soft and doughy, later becoming tense and completely filling the scrotum. It is painless, can be transilluminated readily, and in the ordinary scrotal type the tunica will be found to be fused *tightly to the cord* below the inguinal ring, thereby ruling out hernia or the congenital type of hydrocele, which will be discussed later. It should be emphasized that unless the mass can be satisfactorily transilluminated, the possibility of a solid mass, particularly tumor of the testis, must be considered.

***Hematocele*** is a collection of blood between the layers of the tunica vaginalis, of traumatic origin. It may occur in a previously existing hydrocele, causing sudden additional swelling of the hydrocele with the typical discoloration due to the contained blood, or it may develop after trauma to the normal scrotum. The mass is tense, firm and purplish in color. The testis is indistinguishable on palpation. Rest, elevation of the scrotum and cold compresses may bring about resorption of the blood. In some instances the contained blood may be aspirated before it is resorbed or organ-

particularly pain referred from the left seminal vesicle, before a diagnosis of symptomatic varicocele is made. However, should all other possible causes be ruled out, a painful varicocele may be treated by surgical excision of the majority of the congested veins. The wearing of a suspensory will afford only temporary relief.

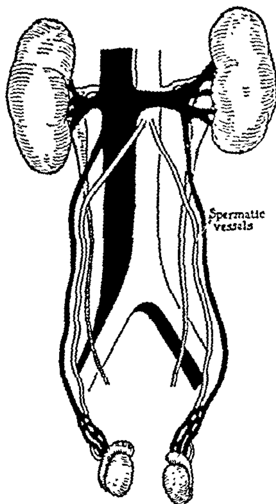



Figure 321. Blood supply of the kidneys and vessels of the spermatic cords.

### Miscellaneous

***Vasoligation.*** Indications for vasoligation include sterilization of the male and interruption of the vas in order to protect the testis and epididymis from infection descending from the prostate and seminal vesicles.

With use of a local anesthetic a wheal is raised in the skin of the scrotum and the vas is anchored just beneath this area with a clamp; a short incision is made in the skin (Fig. 322*A*), and the vas is prolapsed, cut and ligated on each end (Fig. 322*B*). If sterilization is desired, it is of added value to double the cut ends of the vas back on themselves so that they face in opposite directions to prevent later recanalization (Fig. 322*C*). A single catgut suture is taken in the skin of the scrotum (Fig. 322*D*) and the patient remains ambulatory. A suspensory may be worn for a brief interval to relieve discomfort after the procedure. When vasectomy is done for purposes of sterilization, it is well to remember that the ejaculate will still contain viable spermatozoa for a period up to six weeks after the vasa have been inter-

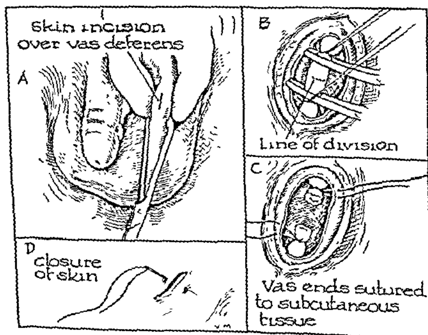



*Figure 322.* Technique of vasoligation.

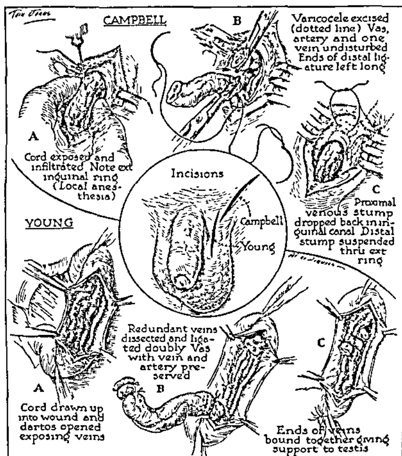



*Figure 320.* Operative treatment of varicocele. The technique of Campbell is shown in the upper half of the illustration and that of Young in the lower half. (By permission of Surg, Gynec. & Obst[7] and Johnson & Johnson)

TUMORS

Benign tumors, such as lipomas and tumors of connective tissue origin, are occasionally encountered. They are recognized as such after surgical excision and microscopic study of the tissue. Malignant tumors of the cord, usually sarcomas, fortunately are extremely rare. Hydrocele of the cord is an uncommon lesion appearing as a localized, smooth, painless, movable swelling in the upper portion of the scrotum. It is sometimes mistaken for a solid tumor of the cord, a third testis or some other bizarre condition It is due to a localized accumulation of hydrocele fluid between the layers of the tunica vaginalis surrounding the cord fused above and below the limits of the lesion. Treatment consists in excision of that portion of the tunica vaginalis if the lesion is symptomatic

*Varicocele* (Fig. 320) is a condition in which the pampiniform plexus of veins along the spermatic cord becomes dilated. Most varicoceles occur on the left side, because the left spermatic vein enters the renal vein at a right angle, necessitating an abrupt turn in the blood flow at this point, with resulting congestion lower down, whereas on the right side the spermatic vein enters the vena cava obliquely (Fig 321) For this reason, should a varicocele be observed on the right side, the right abdominal and retroperitoneal areas should be immediately investigated for a possible tumor exerting pressure on the right spermatic vein. These include renal tumors and retroperitoneal sarcomas. The usual varicocele on the left side develops gradually, whereas the obstructive varicocele on the right forms rather rapidly. Most left-sided varicoceles are asymptomatic and require no treatment. The patient who complains of pain in the left side of the scrotum and has a varicocele may well have had the varicocele long before the pain occurred. For this reason it is always necessary to rule out other possible causes of pain in the scrotum, including

*Epididymitis occurring in the undescended testis* can be recognized, if the testis is in the inguinal canal or at the external ring, as a palpable, inflammatory, tender mass, but if the testis is located intra-abdominally, the symptoms will simulate those of the "acute abdomen."

Treatment of the acute stage includes rest and support of the scrotum by a suspensory or an adhesive bridge across the thighs (Fig. 323) and cold compresses until the acute phase of the disease subsides. One of the sulfonamides or antibiotics should be employed in doses sufficient to produce an adequate blood level. The lesion should be carefully observed daily for evidence of suppuration, which requires prompt surgical drainage in order to protect the testis from infection and destruction. In neglected cases this will occur and requires orchidectomy. After resolution of epididymitis, a firm, painless swelling of portions of the epididymis may remain for life; this is of no significance except as a possible cause of obstructive sterility. In some instances the vas deferens may be found on palpation to be beaded, as a result of fibrotic changes after healing of the infection; this also may contribute to obstructive sterility. Chronic recurrent epididymitis is possible on one or both sides, with frequent flare-ups of either side after minimal trauma or any of the other predisposing causes. If such episodes continue to occur, vasoligation is necessary to protect the involved side from further inoculation from the prostate or vesicles. This will interrupt the cycle and permit permanent resolution of the infection. Vasoligation results in sterility, which is usually of no significance, as most patients with chronic recurrent epididymitis will already have obstructive sterility on the involved side.

*Tuberculous epididymitis* occurs by extension from the genital tract or by way of the blood stream from some distant focus. The onset may at times be sudden, simulating that of an ordinary acute infection, or it may be gradual, appearing as a chronic, irregular, firm and only slightly tender swelling of the epididymis. The vas deferens may become beaded and thickened. In long-standing cases cutaneous fistulas may occur. The testis may also become involved. The disease should be suspected in any chronic lesion of this description with gradual onset, particularly in one known to have some other focus of tuberculosis. If a fistula is present with purulent drainage, it is usually easy to identify the tubercle bacillus in acid-fast stains of the discharge. Treatment usually consists in epididymectomy with removal of as much of the vas as can be reached and excision of any involved cutaneous areas, followed by administration of streptomycin at least long enough to insure complete healing of the scrotal wound. Should the testis be involved it, of course, should also be removed.

### Tumors

*Spermatocele* is a cyst of the epididymis caused by obstruction of some of the seminiferous tubules with accumulation of seminal fluid in the sac. The fluid may be clear and watery or opaque because of large numbers of spermatozoa. Cysts containing opaque fluid obviously cannot be transilluminated. Palpation reveals a smooth globular mass, either rigidly attached to, or freely movable above, the epididymis because of the presence of a pedicle. Treatment is unnecessary except in the occasional spermatocele of such size as to cause inconvenience, in which case it can be excised.

## TESTIS

### Congenital Deformities

*Undescended testes* may be unilateral or bilateral and partial or complete. The testes may be intra-abdominal, or their descent may be arrested in the inguinal canal or on the anterior abdominal wall below the external inguinal ring. These cases are divided into true undescended testes and migratory testes. In the latter type the testes move back and forth from the abdomen to the scrotum and the scrotum is well developed. There may be an associated hernia. Such testes usu-

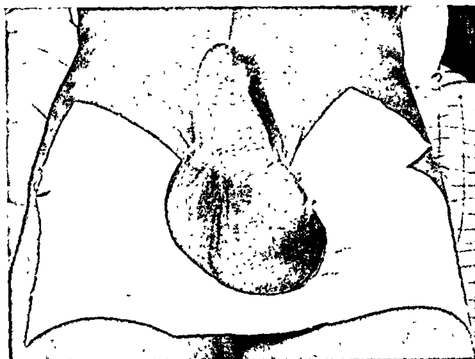


*Figure 323.* Adhesive bridge for support of scrotum.

rupted and that therefore the absence of spermatozoa in the ejaculate should be demonstrated microscopically before the patient can be definitely considered to be sterile.

Re-anastomosis of the vas deferens after previous surgical interruption has been tried with success in order to restore fertility.[8] Vaso-epididymal anastomosis[9] has also been employed with uncertain results in an attempt to circumvent areas of obstruction in the lower end of the vas or epididymis resulting from infection in cases of obstructive sterility. The success of this procedure has also been limited.

***Vaso-anastomosis*** (see Vasoligation).

### EPIDIDYMIS

#### INFECTIONS

***Epididymitis.*** Inflammations of the epididymis may be the result of extension of infectious organisms from the prostatic area along the vas deferens. This includes gonorrhea as well as nonspecific infections occurring in the genital tract. In other instances, epididymitis may follow trauma to the scrotum or may be blood-borne from foci of infection in other parts of the body. Epididymitis may also be precipitated by trauma to the scrotal contents. The condition is manifested by a swollen, tense and hyperemic epididymis. The testis itself is not involved, except in grossly neglected cases of long duration. The prodromal symptoms of this lesion, as the result of extension of infection from the genital tract along the vas deferens, are soreness along the spermatic cord with some tenderness and perhaps some pain referred to the epididymis, even before localized swelling in the epididymis occurs. The acute infection is manifested by fever and intense swelling and tenderness of the epididymis, with the testicle usually indistinguishable on palpation because of the extensive swelling around it. A soft, somewhat fluctuant, inflammatory hydrocele may also be present. The skin of the scrotum is red and tense, but if there is no suppuration the skin will not be adherent to the underlying tissues. This is important, since fixation usually means suppuration and is an indication for surgical drainage.

*Lesions of gonorrheal origin* can readily be recognized by the co-existence of gonorrheal urethritis or prostatitis. Their development usually means violation of the rules of hygiene, which should be observed by all patients with gonorrhea: namely, avoidance of exercise, alcohol and sexual stimulation.

diate orchidectomy, as it would be impossible to be certain of an accurate diagnosis from biopsy or partial removal of the lesion alone.

It should be borne in mind that whereas the classic appearance of an early testicular tumor is that of a localized, firm area projecting from the surface, in atypical cases the tumor may be diffuse and cause enlargement, increased firmness, irregularities of contour or increased heaviness of the organ, or a combination of these. Any or all of these abnormal findings on palpation of the organ should be considered potentially significant.

Likewise, in cases of apparent acute inflammatory disease of the testis, when the lesion fails to resolve completely after an adequate period of conservative therapy, the possibility of tumor should be seriously considered and orchidectomy performed without too much delay.

### MISCELLANEOUS LESIONS

*Insect bites* of the genitalia are seen rather frequently in rural areas but have no special significance. It is well to remember that with the unusual amount of loose, areolar tissue present on the genitalia a disproportionate degree of swelling can occur, leading to undue concern over the significance of the lesion. Hot soaks and cleanliness are all that are required.

*Pediculosis.* Pediculi, usually referred to as "crabs," are small, flat, grayish insects, usually attached to the pubic and scrotal hair. The ova or nits are small, dark, oval bodies seen attached to the hairs. They cause extreme itching. Treatment consists of shaving all hair in the area, followed by repeated applications of mercurial ointment and frequent bathing and change of clothes.

*Allergic reactions* to drugs used locally, either on the external genitalia or within the urethra, will occasionally cause intense redness and swelling of the affected parts. An allergic reaction may also sometimes be produced by some of the dyes used in inexpensive underwear. The appearance of intense swelling and redness of the genitalia may cause both the physician and the patient undue concern over the significance of the lesion. No specific treatment is necessary.

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### GENERAL

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ally will eventually remain in the scrotum without benefit of treatment and the inguinal defect will usually close. Hormonal therapy may hasten permanent descent of the testes, particularly in bilateral cryptorchism. In true undescended testis the scrotum is undeveloped and the testis has never been noted outside the abdomen. Present urologic opinion is that hormonal therapy is of no value in these cases. All such patients should be operated upon preferably by the age of 6 years, in order to attempt to preserve whatever function the testis may have. Likewise, testes in a partially descended position are exposed to repeated trauma from external contacts or pressures on the groin, until they are placed within the scrotum. Also in some instances of partially descended testes there may be an inguinal hernia with the risk of incarceration until repair is made.

### Injuries

***Laceration of the testis*** may be produced by a penetrating wound or severe external trauma. The former is easily recognized by inspection and the latter will be suspected by a continually progressive hematocele. The testis should be promptly exposed and the lacerated area sutured both for hemostatic purposes and to restore the normal anatomic relations The scrotum should be drained by a small Penrose drain and a tight dressing applied to prevent further bleeding by compression

***Dislocation of the Testis.***[10] Violent blows to the genitals may dislocate one or both testes The direction in which the testis is dislocated will depend upon the direction of the force causing the trauma. It may be found in the inguinal canal, beneath the skin of the lower abdominal wall or even in the thigh. It is located by palpation and may be restored to its normal position by manual manipulation or, in extreme instances, by surgical correction.

***Traumatic Hydrocele.*** A transient hydrocele will frequently accompany traumatic injuries to the scrotal contents. Swelling rapidly develops and appears as a smooth mass occupying one side of the scrotum, which is not particularly tender and which can be transilluminated. The skin of the scrotum itself may be somewhat edematous. Treatment consists of rest, support and cold applications, after which the serous effusion within the tunica vaginalis will usually resorb in contradistinction to the behavior of the nontraumatic type of hydrocele (see p. 434).

***Torsion of the Testis*** (see Spermatic Cord, p. 435).

### Infections (see Epididymitis, p. 438)

***Infectious orchitis*** is usually secondary to epididymitis but may follow trauma or blood-borne infection. It is characterized by acute pain and tenderness with fever and nausea. If not controlled promptly by rest, support, cold compresses and appropriate chemotherapeutic agents, orchidectomy will be necessary. Operation is indicated if the lesion persists with continuance of systemic symptoms and localized evidences of suppuration, including softening of the lesion on palpation, fixation of the skin or actual pointing of the lesion in the skin

***Mumps orchitis*** occurs in approximately one-fifth of males in whom mumps develops after puberty. This complication is best prevented by complete bed rest for those with mumps Patients complain of swelling and tenderness of the testes associated with intense pain, fever, nausea and headache. Symptoms usually subside in seven to ten days but in some instances the result is complete atrophy of one or both testes with loss of spermatogenic function. No specific chemotherapeutic agent for this lesion has as yet been found.

### Tumors

Any mass, however small, definitely identified on palpation as being a part of the testis itself, should be explored surgically. If the mass proves to be small and superficial, biopsy may be done before removal of the testis is considered However, abnormal firmness or irregularity of the testis beneath its outer tunic, after surgical exposure, justifies imme-

*Agglutination of the labia majora*, extending from the fourchette to the urethral orifice, may occur in infancy and childhood. In severe cases, the external appearance of the vulva suggests an anatomic abnormality. These children complain of pruritus and burning sensations and may have a discharge, which is more troublesome to their mothers than to them. Agglutination probably results from poor local hygiene. Simple separation of the labia, after the extent of the agglutination has been determined by a smooth silver probe, may be accomplished in the office without anesthesia. Proper hygienic measures followed by application of cold cream will allow complete epithelial replacement.

*Agglutination of the prepuce* about the clitoris, enclosing accumulated smegma, may also be encountered. These children likewise complain of vulvar itching and may be accused of masturbation or may actually engage in masturbation. Separation of the clitoral prepuce may be more difficult to perform in the office and may require a general anesthetic. Proper hygiene and local applications of cold cream will prevent recurrence. Circumcision of the clitoris is rarely performed for any reason.

*Venereal granulomatous lesions*—granuloma inguinale, chancroid and lymphopathia venereum—must be differentiated from tuberculous vulvitis, syphilitic lesions and neoplasms of the vulva. All diagnostic methods must be applied to such lesions including stained smears for acid-fast organisms or Donovan bodies, dark-field examination for spirochetes, skin tests and histologic studies. Each of these venereal conditions may be complicated by secondary infection by a common pathogen, such as staphylococci or the various streptococci, with superimposed cellulitis. After the diagnosis has been conclusively established, the chemotherapeutic agent usually recommended for such a lesion should be given together with additional broad spectrum antibiotics as necessary to control the secondary infection. In chronic vulvar lesions that resist treatment repeated histologic studies are necessary. Excision biopsy may be employed in small lesions but in larger ones biopsies must be taken from many areas. The temptation to perform excision biopsies in offices or dispensaries should be resisted because of the vascularity of this region. Adequate hemostasis may be difficult to obtain unless anesthesia is complete and assistance adequate. Punch biopsies of multiple areas with use of a local anesthetic are easily performed in the office.

*Infections of Skene's or Bartholin's glands* have heretofore been regarded as surgical diseases. Whereas cauterization of Skene's glands was a commonplace surgical procedure a decade ago, chemotherapy has currently reduced the incidence of chronic infection to a minimum. Upon occasion a suburethral gland will become occluded, requiring incision and drainage. Injection of penicillin into the abscess cavity aids in overcoming the infection. Abscesses of Bartholin's glands are less frequently encountered in this day of chemotherapeutics. Incision and drainage of such abscesses can be readily performed under either infiltration anesthesia or Pentothal administered intravenously. Sitz baths taken postoperatively will maintain constant drainage and thus eliminate the necessity for packing the wound. Supplementary treatment with antibiotics is advisable.

*Miscellaneous Lesions of the Vulva. Neurodermatitis* is characterized by intense and unremitting pruritus often producing insomnia, increased irritability and considerable emotional distress. It appears in patches of thickened edematous areas on the vulva which may be bilateral and which show no other signs of inflammation. Excoriations with severe serous discharge from the scratched areas are notable. The condition is worsened by the continued scratching, which is difficult to prevent, even with sedation or restraint. Treatment consists in removal of emotional conflicts, together with adequate sedation. Differentiation from diabetic vulvitis, which is complicated by monilial infection, is necessary to insure a permanent cure. Administration of vitamin A in large amounts seems to be of some

*Chapter 22*

# Female Genito-urinary Organs

*By John C. Weed*

## VULVA[1]

***Injuries.*** Lacerations of the perineal floor or vulva may occur as a result of trauma. Such injuries are produced by blunt objects, such as handlebars, fence pickets or wooden chairs. Also, serious lacerations may result from forceful coitus. Pain is severe because of the rich nerve supply in this region, but more alarming to the patient than pain is hemorrhage. The vascularity of this area coupled with the loose areolar tissue of the vulva allows bleeding to continue unchecked by retraction of vessels. Ecchymosis and hematomas may be extensive and may develop after relatively minor superficial contusions.

The management of lacerations of the vulva and perineum depends upon the extent of the injury. Small ones giving rise to relatively minor complaints can be repaired in the office, provided the extent of the injury can be determined. Careful cleansing, inspection, probing of the wound and adequate hemostasis by primary suture will yield a satisfactory result. Hymenal tears produced at initial coitus rarely require suturing. More severe lacerations, especially those extending into the vagina and approximating the urethra, the rectum or the bladder, will require treatment in the hospital, with blood replacement and general anesthesia. Frequently the extent of the wound cannot be determined except under a general anesthetic, at which time equipment for repair of the wound should be available. Observation of hematomas is necessary prior to the decision to evacuate them. Such a decision should be governed by extent of the hematoma and local pain. Small nonprogressive hematomas should be treated conservatively. Evacuation of large hematomas of the perineum should not be attempted without preparation for extensive exploration of the region.

***Vulvovaginal Infections.***[2] Infectious processes involving the vulva, vagina, or both, are rarely of surgical importance.

*Superficial infections,* such as those due to monilia or trichomonads, sometimes produce a bloody discharge from the vagina or punctate ulceration of the vulva and vagina. These infections are characterized by a purulent discharge in which the presence of the causative organism can be detected in fresh hanging-drop preparations. Symptoms are local and edema is rarely present. Treatment of yeast organisms is most satisfactory with such agents as boric acid capsules intravaginally, propionic acid derivatives in paste or powder and gentian violet applications. Nystatin, an antibiotic agent, is a useful addition to the fungicidal drugs Persistent monilial vulvitis that is resistant to treatment suggests the presence of diabetes mellitus. Many agents have been utilized in the treatment of *Trichomonas vaginalis* vaginitis and vulvitis, including arsenical preparations such as acetarsone, Milibis and Devegan in capsules as well as Floraquin suppositories.

*Acute cellulitis* of the vulva may occur as a complication of neoplastic processes (see below) or of rectal and anorectal diseases with extension anteriorly into the areolar tissue of the vulva Such infectious processes cause considerable intracutaneous edema, increased heat, redness and local pain. Differentiation from superficial infections is relatively easy.

seated tumors of the underlying structures are impossible to differentiate. Tumors of Bartholin's glands may be disregarded as chronic bartholinitis until their size or ulceration necessitates exploration. Similarly, hidradenomas cannot be distinguished from Bartholin adenomas without microscopic examination. Nodularity in such a deep-seated vulvar tumor is an indication for surgical excision.

*Malignant neoplasms* of the vulva include epidermoid carcinoma, basal cell carcinoma, carcinoma of the clitoris and melanoma. Carcinoma of Bartholin's gland and carcinoma of the urethra extend to the vulva and their site of origin may not be clear. The malignancies of epithelial origin may arise in any area of the vulvar epithelium. Symptoms are minimal, perhaps only intermittent itching or watery secretions. When ulceration develops, bleeding directs the patient's attention to the lesion. Unfortunately, symptoms develop slowly so that diagnosis is often delayed. As already noted, malignant changes occur in the margins of *chronic* venereal ulceration. Likewise, malignant change may also occur in association with leukoplakia which the patient has accepted for many years.

The diagnosis of vulvar malignancy can be made only by microscopic examination of biopsied material. Occasionally, a satisfactory diagnosis can be made from a scraping of the lesion. More often, however, multiple biopsies from the periphery of the lesion are required. Intraepithelial carcinoma of the vulva occurs but is considered by many to be a phase in the development of invasive carcinoma.

The treatment of vulvar malignancies, whatever their origin, is a major surgical undertaking including radical vulvectomy and inguinal and pelvic lymph node removal. Melanomas comprise only about 5 per cent of vulvar malignant tumors, but the prognosis of such neoplasms is poor. Pigmented vulvar nevi should be excised, therefore, especially those 0.5 cm. and larger in diameter and those subjected to trauma.

Other lesions of the vulva that are potentially malignant are the hyperplastic areas of leukoplakia. Clinical differentiation of these areas from epithelioma and from the lesions of kraurosis may be difficult. In the presence of ulceration or in lesions showing progressive enlargement, excision biopsy or vulvectomy should be performed. Systemic treatment of leukoplakic vulvitis with large amounts of vitamin A, with or without oral administration of dilute hydrochloric acid, has been beneficial to some patients. Estrogenic therapy has been utilized both orally and by injection. Response to hormones is unreliable, and long-continued use may occasion undesirable side effects. The possibility of obscuring malignant tumors in this region should be borne in mind.

### VAGINA

***Foreign Bodies.*** In small children with a vaginal discharge the possibility of a vaginal foreign body must be suspected. A history of the introduction of a bobby pin, safety pin, match stick, crayon, bean, or the like, is unusual. Unless suspected, the vaginitis and resulting discharge will not respond to treatment. The foreign body may be discovered by rectal examination, accompanied by gentle probing of the vaginal tract with a blunt silver probe, by roentgenography, if metallic, or by examination of the vagina with a Kelly urethroscope. In prepubertal children the vagina can be visualized with the child in the knee chest position and the examiner using a head mirror and reflected light. The foreign body can then be grasped with a small blunt hemostat and withdrawn. Anesthesia is rarely necessary.

Although rare, foreign bodies may be found in the adult vagina. Usually these are forgotten tampons, neglected pessaries or contraceptive devices. A profuse malodorous vaginal discharge, often sanguineous, results from such neglect. Removal of the offending foreign body, followed by a series of cleansing douches, will provide relief.

***Vaginitis.*** Bacterial vaginal infection in the infant or prepubertal child may

value and single applications of a 1 per cent solution of podophyllin in alcohol may give considerable relief. Hydrocortisone ointment applied locally will give temporary relief, but recurrence is inevitable if the primary cause of the emotional disturbance is not corrected. In cases of many years' duration surgical removal of the vulva may be the only effective remedy.

*Herpes Progenitalis.* The vulva is susceptible to herpetic infection comparable in every respect to herpes labialis. The former is characterized by small vesicles surrounded by edema and inflammatory reaction at the base, which cause considerable discomfort as well as pruritus. It is resistant to treatment and usually runs a protracted course However, keeping the vulva dry by application of drying powders, and weekly subcutaneous injections of smallpox vaccine for from five to seven weeks, may be helpful.

*Pediculosis Vulvae* Parasitic infections of the vulva, which occur infrequently, are characterized by minute red areas with excoriations produced by scratching Secondary inflammatory changes may occur in these regions also. The diagnosis, of course, is made easily by identification of the parasite by use of a magnifying lens. Shaving the area and application of insecticidal preparations are effective. The latter should be employed with care, since the vulva does not tolerate chemical preparations as well as other tissues of the body.

*Condylomata Acuminata.* The origin of this lesion is obscure but it is generally found in association with poor local hygiene. It is characterized by small polypoid growths which vary in size from minute papillary lesions to those measuring as much as 5 mm. across. The areas infected are chiefly the labia minora and majora and the fourchette. Lesions do extend up into the vagina and around the anus. Associated with these polypoid growths is a watery discharge which is so irritating as to cause persistent pruritus. Bleeding seldom occurs. Patients with condylomata acuminata may be treated in the office by weekly applications of podophyllin ointment (33 per cent) directly to the lesion. Since podophyllin is a strong cutaneous irritant, it should be applied cautiously. The lesion may be destroyed with the cautery if podophyllin proves unsatisfactory. Improvement of pelvic hygiene is necessary in order to prevent recurrence.

*Tumors.* A large variety of neoplasms may develop in the vulva. In addition to the common neoplasms of the integument generally, tumors of Bartholin's glands, the sweat glands and the clitoris may confuse the picture.

*Soft swellings* with either narrow or broad pedicles may develop gradually. They produce no symptoms but gradually become more dependent and edematous. Unilateral hypertrophy of the labia minora may develop concomitantly from vascular and lymph stasis. Such tumors are generally lipomas or fibromas. Treatment consists in simple excision under local or general anesthesia. Those soft tumors with a broad base may have projections into the adjacent labium, rendering a simple operation considerably more difficult.

*Cysts of Bartholin's gland* are rarely of surgical importance. Small ones are usually discovered incidentally during examination. Often no history of previous infection can be obtained. A few cysts become large enough to cause discomfort to the patient either when sitting or during coitus. Removal of such glands is a minor surgical procedure but requires complete operating room facilities, since the ramifications of these glands may extend into the vulva and require extensive dissection. Hemostasis may be difficult to obtain. Reconstruction of a functioning Bartholin's gland from a Bartholin cyst in which infection is absent or quiescent can be successful. A simple incision of the gland adjacent to the hymen is made, and the membrane lining the cyst is sutured to the vulvar skin about the circumference of the opening. Little else is necessary other than local hygiene.

*Firm tumors* of the vulva are more difficult to differentiate clinically. Sebaceous cysts involving the vulva need no special mention. However, deep-

dyspareunia or vaginal discomfort, excision under general anesthesia is the treatment of choice. Marsupialization has been employed in some of the larger cystic spaces, but complete removal is preferable. What may appear to be a minor procedure may become an extensive operation. Small inclusion cysts of the perineal body are relatively frequent in parous women. These are of little consequence and frequently are excised in conjunction with other restorative plastic procedures.

*Carcinoma* of the vagina is a relatively rare surgical lesion comprising about 1 per cent of female genital malignant tumors. The condition should be suspected in any indurated and ulcerative lesion of the vagina and the diagnosis is made by adequate biopsy. The ulceration accompanying a neglected pessary heals readily. Persistent ulceration probably indicates that malignant changes have occurred.

## URETHRA

*Cystic tumors* are not uncommon along the length of the urethra. These are the result of infection in the paraurethral gland, the ducts of which become occluded. The acute phase is treated by incision and drainage and local injection of penicillin. Bleeding may be profuse and difficult to control. *Chronically infected glands* which act as a source of recurrent urethral infection should be cauterized under local or general anesthesia.

*Suburethral Abscesses.* Incision should be avoided and drainage should be accomplished through the urethra if possible. Such incisions may convert a paraurethral abscess into a urethral fistula. Similarly, vaginal incision of a urethral diverticulum is undesirable. Urethroscopic examination of cystic lesions about the urethra is necessary to exclude diverticula. When present these are excised under general anesthesia with reconstruction of the urethra about an indwelling catheter and adequate support with pubocervical fascia.

*Urethral tumors* may be benign or malignant. The commonest type is the *caruncle,* a soft, friable, reddened and exquisitely tender tumor. It develops at or near the urethral meatus and is subject to recurrent irritation from voiding, pressure of clothes and toilet tissue. Bleeding may occur intermittently. Small *benign polyps* may also occur within the urethral canal but are rarely of surgical significance. Removal of caruncles or benign polyps can be readily accomplished by fulguration in the office under local anesthesia. Repeated dilations of the urethra should follow such treatment in order to prevent development of stricture.

*Carcinoma* of the urethra is a rare tumor which is difficult to diagnose early. Biopsy of any lesion near the urethral meatus that is friable and hard is mandatory to exclude carcinoma. Treatment is a major problem involving judicious application of irradiation and possibly surgical attack in early lesions.

## CERVIX

*Erosion, Ectropion and Eversion.* Under the influence of hormonal changes in girls at the time of puberty the columnar, mucus-secreting epithelium from the cervical canal may extend beyond the cervical portio for varying distances. This epithelium, being thin, has a red granular appearance and bleeds easily following trauma. The glands of this epithelium, which secrete mucus, are infected to varying degrees and the amount of secretion is proportional to the amount of infection. This lesion, which is commonly called erosion of the cervix, is usually detected at the initial vaginal examination in women many years after puberty.

A similar lesion follows incompletely healed obstetrical lacerations. In such cases the external os has been torn so that it is no longer 2 to 4 mm. in diameter, but enlarges to 2 to 3 cm. in diameter. When a speculum is introduced into the vagina, the lips separate, leaving a reddish granular area similar to that of congenital erosion. These are benign lesions and require only cauterization with the electric nasal tip cautery. Chemical cauterization (silver nitrate solu-

occur, giving rise to a bloody or mucopurulent discharge. Although less common than formerly, Neisserian infection must be excluded by smear and culture. Bacteriologic study often reveals a nonspecific infection which may be treated by parenteral administration of antibiotic and chemotherapeutic agents. Rarely, infestation with trichomonads or pinworms may be demonstrated.

In the adult, vaginitis may also be accompanied by a bloody discharge, but bacteriologic examination is seldom informative. During the reproductive years infection of the vagina is more commonly produced by protozoa or monilia. Profuse redness of the vaginal mucosa with punctate hemorrhages or hemorrhagic areas may be noted. In none of these conditions is surgical therapy necessary, although the ulcerative lesions of amebic vaginitis and syphilis may be confused with ulcerated malignant tumors. Demonstration of amebas, trichomonads or yeast cells in the fresh smear or of spirochetes by darkfield examination may prevent unnecessary surgical treatment. Granulomatous lesions of the cervix may extend into the fornices. In such lesions differentiation must be made by smear, darkfield examination and biopsy.

Senile vaginitis, wherein no protozoal, fungal or bacterial agent is demonstrable, is characterized by a serosanguineous discharge. Superficial punctate hemorrhagic ulcerations are present in the atrophic mucous membrane. Differentiation from vaginal carcinoma (see below) is made by cytologic study, vaginal smears or biopsy. Response to estrogenic suppositories is prompt.

*Injuries.* Traumatic lesions of the vagina include perforations of the vault and vaginal walls by coitus or by abortifacient agents, such as pencils, lemon sticks or hatpins. Occasionally, hemorrhage from such wounds is profuse. These wounds must be explored under general anesthesia following scout films of the abdomen with the patient in the upright position to determine the presence of pneumoperitoneum, in which event laparotomy should be performed. Proctoscopic examination of the rectosigmoid is also necessary. Penetrating wounds without pneumoperitoneum or rectal damage should simply be sutured. In neglected cases, closure is dangerous because of the possibility of pelvic cellulitis.

*Chemical burns* may result from injudicious use of vaginal medication. Severe burns of the vaginal fornix not infrequently result from potassium permanganate tablets, either introduced directly or when incompletely dissolved in douches. These ulcerations are deep, necrotic and infected. Diagnosis is difficult unless the etiology is suspected. Treatment is supportive, with adequate cleansing and administration of antibiotics to overcome the secondary infection.

*Malformations. Anomalies of the Hymen.* Imperforate hymen is usually encountered at the age of puberty; however, occasionally an imperforate hymen will exist for many years during which extensive enlargement of the vagina, uterus and tubes occurs with the development of hematometra and hematocolpos. The imperforate hymen should be excised under Pentothal anesthesia in a cruciate manner in order to evacuate the retained menstruum completely and to maintain an adequate opening into the vaginal tract. Hemostasis must be secured by sutures. *Cribriform* or *septate hymen* is incised in a similar manner. Dilation of a *rigid hymen* may be possible as an office procedure with the use of adequate lubrication and graduated dilators.

*Septa of the vagina* may extend from the fourchette to the vaginal vault or may be incomplete above or below. Removal of the septum is not important unless vaginal delivery is anticipated. Under such circumstances the septum is divided throughout its length and the raw surface closed with a continuous chromic 00 suture for hemostasis. A Penrose rubber drain is placed between the raw surfaces for about 24 hours.

*Tumors. Cystic tumors* of the vagina are frequently encountered. Many of these represent remnants of Gartner's duct and are inconsequential. If their size causes

patient anesthetized. Periodic dilation of the cervix is necessary to prevent recurrence.

*Benign Neoplasms.* Polyps extruding from the endocervical canal are commonly encountered. They may occur in patients of any age but are relatively more frequently seen in women nearing the menopause. They may be entirely asymptomatic but are usually associated with a chronic vaginal discharge. Occasionally, spotting of blood occurs spontaneously or after coitus. Underlying the development of polyps is a mild chronic endocervical infection. Treatment consists in removal of the polyp, with cauterization of the base (Fig. 321). Torsion of the pedicle with a sponge forceps will usually prove satisfactory, but if possible excision of the base with a punch biopsy forceps is recommended. Histologic examination is advisable, since a small percentage of these is malignant. If a polyp is noted in a woman who has a history of spotting and who has undergone the menopause, diagnostic curettage and examination of the endometrium also are mandatory.

***Leukoplakia*** of the cervix may be suspected on inspection as a raised, slightly irregular surface with a whitish color. This area will not color with the application of iodine solution, and biopsy will establish the diagnosis Excision biopsy with light cauterization will suffice, but periodic examinations with the study of vaginal smears are necessary.

***Hemangiomas*** of the cervix are curiosities which require treatment only if they bleed. Biopsy of such a cervix may lead to profuse bleeding. These lesions are characterized by a usually well circumscribed, smooth, soft, port-wine-color surface epithelium which blanches under pressure. Should such an area require biopsy, hospitalization is urged because of the possibility of uncontrollable bleeding.

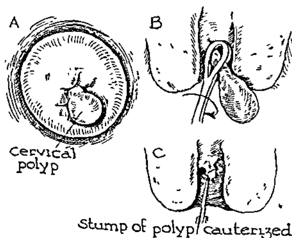



Figure 321. Technique for removal of cervical polyps.

*Malignant Disease.* The cervix is the most frequent site of malignant disease in the female. Because of the accessibility of this organ the diagnosis should be made early. Nevertheless, an early diagnosis is made in only one of four or five cases. Most cervical carcinomas are epidermoid, arising near the squamocolumnar junction at the external os. Only relatively few arise within the endocervical canal. Suspicion of cancer is the foremost aid in establishing the diagnosis. Early cancers of the cervix produce no symptoms but can be found on routine examination. Many unsuspected early invasive cancers are being found by study of vaginal smears, and many more pre-invasive lesions, carcinoma-in-situ, are so demonstrated. More advanced lesions cause a watery discharge first, then a bloody discharge, which may be confused with menstruation and which may occur after coitus. Pain is present only in advanced cases. Carcinoma should be suspected when any friable lesion is found upon examination. Palpation of such an area would reveal a hard and irregular surface of different texture from the normal cervix. Tissue may be obtained by scraping the lesion or by a punch biopsy. Hemostasis may be difficult to obtain after biopsy, but packing the vagina with absorbable gauze or cauterization of the bleeding point should prove successful.

Far-advanced lesions are easily diagnosed because of the induration of the upper vagina, the large craters surrounded by dense and nodular tissue with fixation of the vaginal vault, and the nodular infiltration of the parametrium or middle third of the vagina. Treatment of cervical carcinoma is a major problem.

tions, Negatan and iodine) yields greatly inferior results, although it has many staunch advocates. Prior to cauterization, careful examination of the cervix is necessary to eliminate the possibility of early malignant changes. Study of the exfoliated cells by the vaginal smear methods introduced by Papanicolaou or the scraping technique of Ayre will reveal malignant cells in a high percentage if such a lesion is present. Examination of vaginal smears from office populations and screening of large groups of women have demonstrated that unsuspected cervical neoplasms can be found. Moreover, many precancerous lesions, not previously suspected, can be diagnosed. Suspicious cells in smears indicate more extensive study by biopsy or by surgical conization of the cervix. It is at the squamomucosal junction that the earliest malignant changes develop, and these may occur at any age. Such early lesions cannot be recognized by inspection or palpation and must be demonstrated by histologic study, whether by the smear technique or by direct biopsy. Application of iodine solutions (the Schiller test) will aid in determining where the biopsy should be done. However, erosions, ectropions and eversions will fail to stain with Lugol's iodine just as will malignant disease of the cervix. Areas of the cervix that will not stain a chocolate brown color with iodine are those in which biopsy is indicated.

*Cystic Cervicitis.* If erosions of the cervix have existed for considerable periods of time and if epithelization of the cervix by squamous epithelium has continued, mucous glands of the endocervix may become covered by squamous epithelium leading to mucous retention cysts. Such a cervix may be filled with innumerable mucous cysts varying in size from that of a millet seed to that of a grape. The contents may be clear or opalescent and the epithelium covering them may be thin to quite thick. The cysts have little importance except that they harbor a mild chronic infection. Treatment consists of simple puncture and destruction with a nasal tip electric cautery.

*Ulcerative Lesions.* Infectious agents which may affect the vulva or vagina may also cause lesions of the cervix. These include granuloma inguinale, chancroid, syphilis and tuberculosis. Such lesions produce a foul serosanguineous discharge but patients usually seek treatment because of irregular vaginal bleeding. Pain is rare. The primary lesion of lymphogranuloma inguinale is rarely encountered. Study of ulcerations of obscure etiology should include stained smears for Donovan bodies, darkfield and serologic examinations and biopsy. When a nonspecific granuloma is reported from the biopsy specimen, cultures may be necessary to identify the offending agent. The true diagnosis must be suspected early, for indiscriminate use of cautery may delay the diagnosis for weeks. Treatment consists in institution of the specific medical regimen for the individual etiologic agent. This includes essentially parenteral administration of antibiotic and chemotherapeutic agents, together with local cleansing.

*Stricture or Stenosis.* Congenital stricture of the cervix is rare. At puberty hematometrium develops. Such a lesion requires hospital investigation under anesthesia. Much more often, however, stenosis of the cervix is acquired as a result of overenthusiasm with surgical scalpel or electric cautery. Amputation of the cervix, which was formerly a popular procedure, was among the foremost causes of acquired stenosis. The trend in popularity towards electric conization of the cervix has replaced surgical amputation of the cervix as the most frequent cause of stenosis of the cervix today. Cervical stricture or stenosis contributes to menstrual dysfunction, dysmenorrhea and dyspareunia. Prolonged stenosis of the cervix may result in pelvic endometriosis. The diagnosis of cervical stenosis or stricture becomes apparent when an attempt is made to sound the uterine canal. Often this procedure is omitted from pelvic examination. Mild stenosis of the cervix can be overcome in the office, utilizing graduated Hegar dilators to size 16. Holding the cervix with a tenaculum aids in the performance. Anesthesia is seldom required. In the severer forms of stenosis dilation should be accomplished in the hospital with the

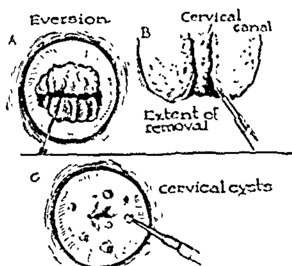



Figure 327. Cauterization of the cervix.

effort to penetrate the cervical substance except when nabothian cysts are encountered. The cervical canal should not be entered except when there is a definite thick, mucopurulent discharge indicating the presence of endocervicitis. In such cases the endocervical canal should be lightly cauterized for approximately ¼ to ½ inch. Intensive destruction of tissue with electric cautery should be avoided.

The healing processes that follow cauterization allow the squamous epithelium to grow over the cauterized area to the external os. This process can be aided by use of mildly acid douches daily for several weeks. A simple cleansing douche is mildly acidified with lactic or acetic acid or a detergent such as pHisoderm. Medicated douches have a more psychologic than therapeutic effect. The use of antibiotic, chemotherapeutic or hormone preparations is rarely necessary. The area cauterized should be the minimum necessary for eradication of the lesion. Reexamination and recauterization six weeks later is preferable to scarring the cervix with deep cauterization. The cervical canal should be dilated routinely at follow-up examinations to prevent cervical stenosis.

### INTERNAL GENITALIA

Relatively few diseases of the internal genitalia can be treated satisfactorily in the office.

*Retroversion of the Uterus.* Displacement of the uterus occurs in approximately 20 per cent of all women, but in only a few are symptoms produced. When it is desirable to determine whether retroversion of the uterus is symptomatic, the proper insertion of a vaginal pessary may be valuable. Pessaries commonly employed are the Hodge or the Smith pessary of molded plastic. With the patient in the lithotomy position the uterus is manipulated to the anterior position by combined abdominal and vaginal examination. Occasionally, this can be facilitated by use of the rectovaginal approach. Similarly, downward displacement of the uterus by means of a tenaculum upon the cervix will often aid in converting the retroversion to anteversion. A pessary may be inserted with the superior rounded end in the posterior fornix and the blunt inferior end behind the symphysis pubis. Care should be taken to fit a pessary that does not impinge upon the pubis. A properly fitted pessary should allow the finger tip to be inserted between the pessary and the pubic bone without discomfort. The position of the uterus should be ascertained after insertion of the pessary and the performance repeated if the fundus is not in the anterior position. The knee-chest position is of value in converting a retroverted uterus to the anterior position in difficult cases. A properly fitted pessary may also aid in determining the amount of discomfort caused by beginning uterine prolapse.

### TUBAL INSUFFLATION[3] AND UTEROSALPINGOGRAPHY

Determination of tubal patency is important in assessing female fertility. Also, the diagnosis of chronic salpingitis can be confirmed by demonstration of nonpatency. Tubal insufflation is an office procedure requiring the usual examining instruments and a device for introducing carbon dioxide under graduated manometric pressure. Carbon dioxide has proved to be far safer than oxygen or air, as it eliminates the hazard of air embolism.

With the patient on the examining table and her feet in stirrups, the cervix is visualized with a self-retaining bivalve

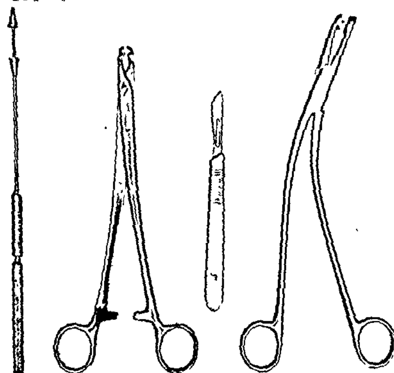


*Figure 325.* Instruments for cervical biopsy.

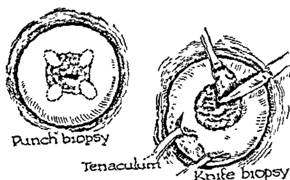



*Figure 326.* Methods of cervical biopsy.

### Technique of Punch Biopsy

Numerous cervical biopsy punches are available (Fig. 325) but probably the most commonly used is the Goodall punch with which crescentic pieces of full-thickness cervical epithelium can be obtained. It may be necessary to hold the cervix with a tenaculum in order to obtain a satisfactory piece of tissue for study (Fig. 326). The cervix is devoid of nerve endings responding to cutting or burning stimuli and the biopsy can be accomplished with minimal discomfort in the office. Postbiopsy bleeding can be controlled readily by lightly cauterizing the base of the biopsied area.

### Technique of "Cold Knife" Conization

If the cervix has no obvious lesion but the vaginal smear leads one to suspect a malignant process, conization is necessary. The entire external os is circumscribed after surgical cleansing. The area on the external portion of the cervix to be removed should include all tissue that *does not* turn chocolate brown with *Schiller's solution.* The upper end or apex of the cone should extend no less than 1 cm. up into the cervical canal. Removal of this cone by electrosurgical means causes charring of the tissue and leads to an inadequate diagnosis. Bleeding, usually moderate, is controlled by packing for 24 hours. Conization requires hospitalization and regional anesthesia.

### Technique of Cauterization

Cauterization is performed with an electric nasal tip cautery heated to a copper color (Fig. 327). Anesthesia is unnecessary and if the patient is reassured beforehand, discomfort will be minimal. Cooling devices, such as a compressed air blower or a water-cooled speculum, greatly reduce the discomfort. The cautery is used lightly on the cervix without

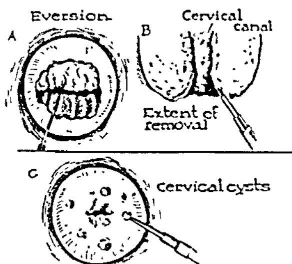



*Figure 327.* Cauterization of the cervix.

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With the patient on the examining table and her feet in stirrups, the cervix is visualized with a self-retaining bivalve

speculum. The vagina and cervix are cleansed with a detergent and painted with an antiseptic solution; the cervical canal is then probed. An olive-tipped cannula is inserted into the canal and the olive tip is held firmly against the external os, to assure an airtight connection. The gas is administered slowly so that the pressure in the manometer rises gradually. Tubal patency is evident when the manometer falls rapidly. Tubal occlusion is diagnosed when the manometer continues to rise to 200 mm. Hg. Since tubal rupture may occur at higher pressures, the pressure should not be allowed to rise higher than this level. Tubal spasm, which may result from instrumentation or too rapid insufflation, can be overcome by repeating the procedure slowly.

Uterosalpingography with a radiopaque medium is useful to confirm tubal patency, as well as to aid in the diagnosis of endometrial polyps, submucous fibroids and uterine anomalies. The radiopaque medium is injected slowly in a manner similar to that for the carbon dioxide. After surgical cleansing of the vaginal tract either fluoroscopic observation or roentgenograms taken during and after the injection provide evidence of tubal patency or obstruction and an outline of the endometrial cavity.

Tubal insufflation and uterosalpingography are contraindicated in women with acute infections of the genitalia, and they should not be done in patients with recent infections of the tubes, as exacerbation may result. Uterine bleeding is also a contraindication to either procedure.

### Endometrial Biopsy

When study of the endometrium will aid in establishing the cause of irregular menstruation or in determining whether ovulation has occurred (for sterility surveys), adequate samples of this membrane can be obtained with a suction curet of the Randall or Novak type. The patient is instructed to come to the office as soon as possible after the onset of bleeding, which would be irregular in the former instance, or at the normal onset of menses in the latter. After surgical cleansing of the vaginal vault and cervix, a sound is passed into the fundus to determine the direction of the uterine canal. The curet is passed into the fundus and four strips of endometrium are removed (two anterior and two posterior) by withdrawing the tip as far as the internal os, reinserting it to the fundus and withdrawing it again. Suction may or may not be applied concomitantly. No anesthetic need be used, and discomfort is moderate and short lived. Endometrial biopsy should not be attempted as a substitute for thorough curettage in incomplete abortions or in women suspected of having an endometrial growth.

### Curettage

Diagnostic and therapeutic curettage requires hospitalization and general anesthesia. With the patient in the lithotomy position, the perineal area and vulva are shaved and thoroughly cleansed with soap or detergent solution. The vagina likewise is thoroughly scrubbed with the same agent. The entire area is next rinsed with a 70 per cent solution of alcohol and painted with a mercurial antiseptic solution. The surgical field is isolated with sterile drapes. A weighted speculum is inserted to depress the perineal body; the cervix is brought into view with a tenaculum. The cervical canal is gently probed with a blunt-ended probe to determine the position of the uterus and the length of the endometrial cavity. Vigorous probing may lead to perforation of the uterus, especially in retroversion of a pregnant uterus. The cervical canal is dilated with graduated sounds of the Hegar type or with the Goodall dilator, to the extent that a sponge forceps can be easily introduced. Obstructions encountered in dilating the cervical canal should be overcome with gentle but firm pressure to avoid perforation.

Prior to the introduction of ring forceps or a sharp curet, the endometrial cavity should again be probed with the blunt probe. Removal of products of

pregnancy is best accomplished with a ring forceps. Use of a sharp curet is seldom necessary or advisable.

For diagnosis of endometrial carcinoma, polyps or hyperplasia, a sharp curet is employed. The entire endometrial cavity should be systematically scraped. Small curets are useful in reaching into the uterine cornua.

Fractional curettage has been suggested to aid in separating, insofar as is possible, lesions of the endocervix and endometrium. Dilation of the cervical canal is followed by thoroughly scraping the endocervical canal, removing the specimen, and finally scraping the endometrial cavity. The use of intrauterine antiseptics or drains has generally been abandoned.

### Culdocentesis[4]

In cases of effusion into the cul-de-sac of Douglas, when differentiation between acute pelvic inflammatory disease and ectopic gestation is difficult or impossible, the simple office procedure of culdocentesis or cul-de-sac puncture (Fig. 328) can be readily performed and will remove all doubt as to the correct diagnosis. It requires no special instruments. With the patient in the lithotomy position and a vaginal speculum in place, the vagina is surgically cleansed. The posterior lip of the cervix is grasped with a tentaculum and the cul-de-sac punctured through the posterior fornix in the midline at about 1 to 1½ inches from the external os. Puncture is performed with a sterile No. 18 spinal needle attached to a sterile 20 cc. syringe with a short length of tubing between, if available. After insertion of the needle, suction is applied and the needle is slowly withdrawn. Intraperitoneal bleeding is characterized by blood which will not clot on standing. Blood which clots within a few minutes was probably withdrawn from the pelvic vein. Pelvic inflammatory disease yields a purulent exudate varying in consistency and color. Occasionally it is serosanguineous. Smear and culture will reveal organisms. Culdocentesis is properly performed prior to colpotomy for drainage of a pelvic abscess.

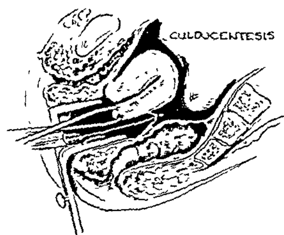



*Figure 328.* Culdocentesis (sectional view)

### Culdoscopy

Visualization of the pelvic contents by culdoscopy requires more elaborate equipment as well as anesthesia. The culdoscope is passed through an incision in the posterior fornix and air is introduced into the pelvis when the obturator of the instrument is withdrawn. The internal genitalia can then be examined. Advocates of culdoscopy point out that exploratory laparotomy can often be avoided. The use of the culdoscope, however, is contraindicated in patients with pelvic adhesions, retroversion of the uterus or tumors filling the cul-de-sac.

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*Part VII*

# The Head

*Chapter 23*

# Minor Surgery of the Eye

*By James H. Allen*

Inasmuch as lesions of the eye have the greatest potentialities for serious permanent disability, all but the most trivial should be referred promptly to an ophthalmologist if the maximum protection is to be afforded the welfare of the patient and the reputation of the general physician or surgeon. However, in some instances, the rapidity of the institution of proper primary measures of care, or the method of transportation of the patient to the ophthalmologist, may determine the ultimate disability. Therefore the following material includes discussions of some problems that actually are major ophthalmic problems but for which proper initial care by the general surgeon, industrial surgeon or general practitioner may considerably reduce the ultimate visual loss or may even save an eye.

## MINOR INFECTIONS OF THE LID

***Hordeolum.*** Hordeolum, or stye, is a localized pyogenic inflammatory process leading to formation of an abscess in a gland of Zeiss. These glands empty into the follicles of the eyelashes; therefore, a stye occurs only at the lid margin.

From the pathologic standpoint the lesion is a typical abscess, usually the result of staphylococcic infection. Contributory causes are eye strain and general debility.

The initial symptoms are pain and tenderness over a localized portion of the lid margin. Redness and swelling follow and gradually the abscess points. Edema of the lid may be extensive and out of all proportion to the severity of the disease, especially if the stye is near the lateral canthus. Preauricular or submental lymph glands often are swollen and tender or slightly painful, depending upon the location of the lesion.

Differential diagnosis includes furuncles, which occur only in the skin of the lid and never point at the lid margin; acute dacryocystitis, which lies slightly nasal to and below the inner canthus; and meibomitis, an inflammation of the meibomian glands of the tarsus, which appears as a vertical yellow streak beneath the tarsal conjunctiva.

A stye has an acute course, points, ruptures, evacuates its contents, and heals even though untreated.

Treatment consists of application of hot wet compresses, incision and drainage. An ointment of 1:3000 bichloride of mercury should be applied to the lid margin between compresses and until the stye has healed. If styes are multiple or recur, the patient should be examined for general disease, such as diabetes mellitus or tuberculosis. In addition, any refractive error should be corrected and vaccine therapy should be instituted.

***Meibomitis.*** Meibomitis is an acute or chronic inflammation of the meibomian or sebaceous glands, which lie in the tarsus and empty along the margin of the lid. The lesion usually is caused by staphylococcic infection associated with chronic conjunctivitis. Other bacteria, however, may be involved.

In the acute lesion the patient has pain in the lid and tenderness over a localized area. Eversion of the lid reveals a yellow line perpendicular to the lid margin beneath the conjunctiva, i e., a gland filled with pus.

The chronic form of meibomitis is a low grade chronic inflammatory proc-

ess involving practically all the meibomian glands. There is no pain, but the patient complains of a sandy sensation in the eye. This form always is associated with chronic conjunctivitis. Mucopurulent, purulent or rancid sebaceous material may be expressed from the glands. Acute exacerbations of the infection may occur.

Treatment of acute meibomitis consists of anesthetizing the conjunctiva with a 5 per cent solution of cocaine and expressing the contents of the glands through their normal openings by pressure applied between a sterile plastic rod and the fingers.

Treatment of the chronic form is prolonged, tedious and difficult, consisting of periodic expression of the meibomian glands and measures to overcome the chronic conjunctivitis. Thus the problem is primarily one for an ophthalmologist.

*Chalazion.* A chalazion is a chronic, low grade, granulation-tissue tumor of a meibomian gland and the surrounding tarsus. The cause is unknown but probably is a low-virulence organism.

Microscopically the lesion consists of round cell infiltration of the gland and tarsus with formation of granulation tissue. Epithelioid and giant cells are present, and the growth is surrounded by connective tissue. The central parts undergo mucoid degeneration. Occasionally chalazia become acutely inflamed as a result of pyogenic infection.

A small, hard, slowly growing nodule arises deep in the lid. The overlying skin is normal and freely movable. Neither inflammation nor edema is present, nor are there any subjective symptoms. After many months the growth may perforate the conjunctiva and a small mass of granulation tissue presents itself upon eversion of the lid.

Secondary infection of a chalazion rarely occurs, but when it does, signs of acute inflammation appear.

The only condition that resembles a chalazion is the rare carcinoma of a meibomian gland, which usually occurs in young persons and presents a granular-appearing mass on the conjunctival surface of the lid and the inner aspect of the lid margin.

The course of a chalazion is chronic and slowly progressive. Chalazia may perforate the conjunctiva and evacuate some mucous or mucopurulent material, but this does not result in a cure since granulation tissue continues to develop or recur.

The treatment is complete excision of the mass. The conjunctiva is anesthetized by topical application of 5 per cent cocaine solution, and the tissues surrounding the growth are infiltrated with 2 per cent procaine solution. A chalazion clamp is applied and the lid everted. The conjunctiva is incised perpendicularly to the lid margin over the entire length of the growth. The growth is dissected out completely; otherwise it will recur. Bleeding is controlled, the chalazion clamp removed, and the lid allowed to return to its normal position. A light dressing is applied to the eye until the anesthesia wears off, or for 6 to 24 hours.

*Furuncle.* A furuncle, or boil, is an acute localized infection of the lid. Edema of the neighboring areolar tissue is a prominent feature. The course is similar to that of a boil elsewhere on the body, i.e., necrosis, suppuration, pointing, drainage and healing.

Three conditions must be differentiated from furunculosis: hordeolum, acute dacryocystitis and orbital cellulitis. A stye occurs only at the lid margin, whereas a furuncle is located in the skin of the lid. Acute dacryocystitis or inflammation of the lacrimal sac must be differentiated from a furuncle at the nasal end of the lower lid. Both are painful and cause redness and induration of the skin. In dacryocystitis, pressure over the inflamed area may cause regurgitation of pus from the puncta, the inflammation lies behind the medial canthal ligament, and the anterior crest of the lacrimal fossa cannot be felt. In furunculosis there is no regurgitation from the puncta, the inflammation lies superficial to the canthal ligament and the anterior lacrimal crest may be palpated. Also in furunculosis the inflammation is limited

above by the medial canthal ligament. Orbital cellulitis produces exophthalmos, limited and painful eye movements and generalized edema of both lids, none of which occurs in furunculosis.

Treatment of furunculosis of the lid, as elsewhere, consists of application of hot compresses, surgical drainage and systemic antibiotic therapy if involvement of the cavernous sinus appears imminent.

### INFECTIONS OF THE LACRIMAL APPARATUS

*Acute dacryoadenitis,* an inflammation of the lacrimal gland, is a rare condition which may appear as a complication of mumps or injuries of the orbit. The signs and symptoms are pain, tenderness and swelling beneath the upper temporal margin of the orbit. Incision and drainage are indicated only if abscess occurs.

*Dacryocystitis,* an inflammation of the lacrimal sac, is always secondary to obstruction of the lacrimal passages. In the newborn, infection of the lacrimal sac results from failure of the lacrimal passages to become patent. The obstruction frequently is due to retained debris in the nasolacrimal duct, but occasionally is due to a membrane-like persistence of epithelium at the lower end of the duct. In older children and adults, obstruction of the nasolacrimal passages may be due to injury or fracture of the lacrimal or nasal bones, infection of the nasal passages, nasal tumors and, more rarely, trachoma, tuberculosis or gumma.

*Congenital atresia of the nasolacrimal duct* is due to failure of the duct to open or to plugging of the lower portion of the nasolacrimal duct. Normally the duct leading into the nose becomes patent just before birth. If this fails to occur or if the passage becomes filled with debris, an obstruction exists and results in epiphora. The parents usually state that the baby has teared since birth. Frequently secondary infection occurs with a purulent discharge in the involved eye. Pressure over the lacrimal sac may cause regurgitation of pus from the puncta, although this sign cannot always be demonstrated. Irrigation of the lacrimal sac by means of a syringe and lacrimal cannula results in return of the irrigating fluid and pus through the puncta.

Cellular debris retained in and obstructing the nasolacrimal passages often may be irrigated into the nose at the time of the initial examination. However, in those cases in which there is superimposed infection the sac may have to be irrigated on repeated occasions before the infection is controlled and the consequent edema subsides so that the debris may be flushed into the nose. All of the exudate should be irrigated from the sac in infected cases. Usually 2 to 5 cc. of sterile saline solution is sufficient. Irrigation should be repeated daily until no exudate appears in the return fluid or until the irrigating fluid flows into the nose. The obstruction usually is relieved simultaneously with control of the inflammation. Should the irrigating fluid become clear and the obstruction persist, the cause is probably a membrane-like persistence of epithelium at the lower end of the nasolacrimal duct. Continued irrigation is useless and the obstruction must be relieved by passage of a No. 1 or No. 2 Bowman probe through this membrane. Both irrigating and probing procedures should be performed by a physician skilled in these methods, since injury of these delicate structures results in scarring and more obstinate or permanent obstruction. Very rarely congenital atresia is caused by anomalous development of the nasal or orbital bones. In these cases the ophthalmic surgeon will have to choose between simple removal of the lacrimal sac with closure of the puncta or, preferably, a dacryocystorhinostomy, an operation which creates a new drainage channel from the lacrimal sac into the nose.

*Acute dacryocystitis* usually occurs in a relatively mild form in the newborn but occasionally may occur in the severe form seen more frequently in older children and adults After obstruction of the nasolacrimal passages, inflammation results from secondary infection. Among the more frequent causative organisms are *Micrococcus pyogenes* var. *aureus* (*Staph. aureus*), *Streptococcus viridans*

and *Diplococcus pneumoniae*. Less frequently gram-negative rods produce the inflammation. The pathologic process consists of a pyogenic infection producing acute inflammation of the mucosa and submucosa of the lacrimal sac, followed by cellulitis of the surrounding tissue which may lead to abscess formation.

The symptoms are pain and tenderness accompanied by redness, induration and swelling of the tissues of the mesial portion of the lower lid and the side of the nose. The submental and the preauricular lymph nodes usually are palpable and tender. When an abscess develops in the tissues around the sac, it may point, rupture the skin and discharge pus for several days. With diminution of the purulent discharge the skin may heal and break down intermittently with a discharge of tears, or a permanent fistula may remain with a continuous flow of tears over the cheek. Before treatment is instituted, smears and cultures should be made to determine the cause of the infection. In the early cases, before an abscess has occurred in the tissues around the sac, the sac should be gently irrigated daily and a suitable conjunctival antiseptic or antibiotic solution should be instilled onto the conjunctiva six times a day until the infection is controlled. After an abscess has formed, irrigation of the lacrimal sac might spread the infection; therefore, drops should be instilled on the conjunctiva hourly while the patient is awake and a suitable antibiotic should be given orally or parenterally until the infection has subsided. Insofar as possible, rupture or incision of the abscess should be avoided, for the development of a fistula complicates the reparative surgery. Neither excision of the sac nor dacryocystorhinostomy should be attempted during the acute or subacute phase of the process. The reparative procedure of choice is a dacryocystorhinostomy after the infection has been controlled and the inflammation has subsided. This operation may be performed even with a persistent fistula, although it is much more difficult.

*Chronic dacryocystitis*, a chronic mucopurulent inflammation of the lacrimal sac, may result from any type of obstruction of the nasolacrimal passages but usually is the sequel to an acute dacryocystitis. As a result of the chronic infection the sac wall becomes thickened. In addition to the original obstruction of the nasolacrimal duct, scarring may be added which produces strictures that may also occur in the sac. The symptoms are epiphora and regurgitation of mucus or pus into the conjunctival sac, with the production of chronic conjunctivitis. There may be slight swelling in the region of the lacrimal sac and pressure on the sac may cause a flow of mucopurulent material from the puncta. Frequently, however, this sign cannot be elicited. Irrigation of the sac will result in return of the fluid and mucopurulent material through the puncta. If one is not skilled in irrigation of the sac, he should not attempt the procedure. However, he may suspect occlusion of the lacrimal passages if instillation of a few drops of a 2 per cent aqueous solution of Mercurochrome into the conjunctival sac does not result in the appearance of the colored solution in the nose or nasopharynx within a few minutes. An aqueous solution of fluorescein might be used for this test. The principles of treatment of chronic dacryocystitis are the same as for acute dacryocystitis, i.e., eliminate the infection, then re-establish drainage of the lacrimal sac into the nose by a dacryocystorhinostomy. Occasionally, because of the patient's age or because of unfavorable local conditions, it may be necessary to remove the sac and close the puncta, but this is rare. Restoration of patency of the nasolacrimal duct following chronic dacryocystitis by the passage of probes usually is unsuccessful.

The principal danger from dacryocystitis, either acute or chronic, is corneal infection. With pathogenic bacteria present on the conjunctiva, a minor abrasion of the cornea is likely to result in a severe infectious ulcer which could lead rapidly to intraocular infection with loss of the eye or, at the least, could result in considerable loss of vision from the scarring of the cornea. For these reasons, as

above by the medial canthal ligament. Orbital cellulitis produces exophthalmos, limited and painful eye movements and generalized edema of both lids, none of which occurs in furunculosis.

Treatment of furunculosis of the lid, as elsewhere, consists of application of hot compresses, surgical drainage and systemic antibiotic therapy if involvement of the cavernous sinus appears imminent.

### INFECTIONS OF THE LACRIMAL APPARATUS

*Acute dacryoadenitis,* an inflammation of the lacrimal gland, is a rare condition which may appear as a complication of mumps or injuries of the orbit. The signs and symptoms are pain, tenderness and swelling beneath the upper temporal margin of the orbit. Incision and drainage are indicated only if abscess occurs.

*Dacryocystitis,* an inflammation of the lacrimal sac, is always secondary to obstruction of the lacrimal passages. In the newborn, infection of the lacrimal sac results from failure of the lacrimal passages to become patent. The obstruction frequently is due to retained debris in the nasolacrimal duct, but occasionally is due to a membrane-like persistence of epithelium at the lower end of the duct. In older children and adults, obstruction of the nasolacrimal passages may be due to injury or fracture of the lacrimal or nasal bones, infection of the nasal passages, nasal tumors and, more rarely, trachoma, tuberculosis or gumma.

*Congenital atresia of the nasolacrimal duct* is due to failure of the duct to open or to plugging of the lower portion of the nasolacrimal duct. Normally the duct leading into the nose becomes patent just before birth. If this fails to occur or if the passage becomes filled with debris, an obstruction exists and results in epiphora. The parents usually state that the baby has teared since birth. Frequently secondary infection occurs with a purulent discharge in the involved eye. Pressure over the lacrimal sac may cause regurgitation of pus from the puncta, although this sign cannot always be demonstrated. Irrigation of the lacrimal sac by means of a syringe and lacrimal cannula results in return of the irrigating fluid and pus through the puncta.

Cellular debris retained in and obstructing the nasolacrimal passages often may be irrigated into the nose at the time of the initial examination. However, in those cases in which there is superimposed infection the sac may have to be irrigated on repeated occasions before the infection is controlled and the consequent edema subsides so that the debris may be flushed into the nose. All of the exudate should be irrigated from the sac in infected cases. Usually 2 to 5 cc. of sterile saline solution is sufficient. Irrigation should be repeated daily until no exudate appears in the return fluid or until the irrigating fluid flows into the nose. The obstruction usually is relieved simultaneously with control of the inflammation. Should the irrigating fluid become clear and the obstruction persist, the cause is probably a membrane-like persistence of epithelium at the lower end of the nasolacrimal duct Continued irrigation is useless and the obstruction must be relieved by passage of a No. 1 or No. 2 Bowman probe through this membrane. Both irrigating and probing procedures should be performed by a physician skilled in these methods, since injury of these delicate structures results in scarring and more obstinate or permanent obstruction. Very rarely congenital atresia is caused by anomalous development of the nasal or orbital bones. In these cases the ophthalmic surgeon will have to choose between simple removal of the lacrimal sac with closure of the puncta or, preferably, a dacryocystorhinostomy, an operation which creates a new drainage channel from the lacrimal sac into the nose.

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long as the infection persists, there is constant danger to the eye. Since spontaneous resolution of dacryocystitis does not occur, these lesions should be treated as soon as they are discovered.

## OCULAR FOREIGN BODIES

The most frequent injury of the eyes is the lodging or embedding of foreign bodies on or in ocular tissues. Small particles with low velocity lodge on the lids, lid margins, conjunctiva or cornea. Many of these are removed by the blinking movements of the lids and the flow of tears stimulated by the irritation they produce. Some, especially those with sharp edges and corners, may become embedded either on or in the conjunctiva, cornea or globe. Others traveling with greater velocity partially or completely bury themselves in the tissue at the point of contact. In this group, approximately two-thirds of those that strike the globe involve the cornea. Finally, high-velocity foreign bodies, either small or large, bury themselves quite deeply.

Ocular injuries produced by foreign bodies are more serious than similar injuries to other superficial tissues and structures because of the ever-present danger of visual loss Abrasions of the cornea may result from movement of the foreign body over the cornea by motion of the lids or eyeball. Mechanical injury and resulting scar produced by a superficial foreign body on the pupillary portion of the cornea may result in considerable distortion or loss of vision. In addition, superimposed infection increases scarring and visual loss. Therefore, since many foreign bodies are contaminated with organisms which are potentially pathogenic for ocular tissues, even minor injuries of this type should be treated skillfully and carefully.

A patient with a foreign body on the conjunctiva or cornea experiences a scratchy or cutting sensation in his eye. This is increased by motion of the lids or eyeball. It is accompanied by an immediate and prolonged increase in flow of tears and an increase in blinking movements of the lids until the patient discovers that the pain is partially relieved by keeping the lids closed and the eyeballs at rest. Some discover that relief is more complete when both eyes are closed. In many cases the pain produces blepharospasm (forced closure of the lids) so that it may be difficult to open the lids in order that the eye may be examined. Opening the lids produces a gush of tears onto the cheek which sometimes washes part or all of the foreign particles out of the conjunctiva. The bulbar and palpebral conjunctival vessels are congested. Careful inspection with adequate illumination and magnification usually will reveal the foreign body.

The above signs and symptoms result from purely mechanical trauma by inert foreign bodies. In those cases in which the foreign material has chemical activity, such as lime dust, burns are produced in addition to the mechanical injury. These lesions will be discussed in the section on *Burns of the Eye*.

In some cases of conjunctivitis the early manifestations are quite similar to those produced by dust or dirt in the eye, namely the scratchy sensation, increased flow of tears and redness of the eye. The symptoms frequently begin in one eye. In these cases a careful search does not reveal a foreign body, and scratches of the cornea are not found. In the course of a few hours a mucopurulent discharge appears on the conjunctiva and sooner or later the second eye becomes involved. Bacteriologic examination (that is, conjunctival culture and scrapings) will assist in establishing the diagnosis.

An accurate history is important in foreign body cases because it helps the surgeon avoid producing damage to the eye in the course of his examination. Specifically and without delay, information should be obtained regarding the circumstances of the injury, the probable nature and size of the foreign body (dirt, sand, metal, glass, and so forth), the method of its access to the eye and its relative momentum, the time of the injury and any previous attempts at removal. Other historical data may be obtained after the extent of emergency has

been determined by examination of the eye.

The patient should be examined in a supine or partially reclining position in a treatment chair with his head placed in a comfortably and firmly adjusted headrest. In addition to good general illumination, strong focal illumination should be available for use with a magnifying loupe. All loose foreign material on the lids should be removed and the lids inspected for injury. The lids should then be opened gently without pressure on the eyeball. The globe should be inspected for evidence of a penetrating wound or laceration. Should such a wound be found, the remainder of the examination must be conducted with extreme caution to avoid further damage to the eyeball, keeping in mind that any pressure on it might result in extrusion of part or all of the contents of the globe; and the patient should be hospitalized for further definitive care by an ophthalmic surgeon (See *Intraocular Foreign Bodies*, below). If no evidence of a penetrating wound of the globe is found, examination and removal of foreign bodies may proceed as described in the following sections.

*Foreign Bodies of the Lids.* Superficial foreign bodies of the lids and lid margins frequently occur in conjunction with multiple foreign bodies of the conjunctiva and cornea. These should be removed at once to avoid their displacement into the eye, but with care to prevent increase of damage to the eye by the conjunctival particles.

Foreign bodies buried in the lids usually are easily located by careful palpation. Often these may be removed through the wound of entry. In some cases it may be necessary to enlarge the wound. Insofar as possible, the incision should be enlarged along the line of a normal lid fold, or parallel with the lid margin. When exposed, the foreign body should be lifted out gently without removal of tissue. If the tarso-orbital fascia is ruptured, it should be closed with 0000 plain catgut to avoid herniation of orbital fat into the lid. The remaining subcutaneous tissues should be allowed to return to position and the skin edges approximated. For linear wounds a 0000 black silk continuous subcuticular suture is most satisfactory. Ragged wound edges should be approximated and matched accurately as one fits the pieces of a jigsaw puzzle. When repositioned they should be sutured by interrupted 000000 black silk sutures placed superficially in the skin. Débridement should not be done. Small wounds need not be dressed but should be kept covered with an antiseptic ointment. More extensive wounds of the lid should be dressed. Antiseptic ointment should be applied and a gauze pad placed on the lids in such a way that the lids will remain closed. The interrupted sutures may be removed after three days and subcuticular sutures after seven days.

Multiple superficial foreign bodies of the skin of the lids, such as occur in various forms of blast injuries, sometimes may be removed by careful scrubbing of the lids with a small, sterile, stiff-bristled brush. If this is done, the conjunctiva should be anesthetized and the lid supported by a lid plate inserted into the conjunctival sac. The lid plate also serves to protect the eye. Upon completion of the procedure the conjunctiva should be examined carefully for any foreign material that might have been dislodged from the lids. These particles should be removed. The lids then should be closed and covered with an antiseptic ointment, and a firm dressing should be applied.

In some instances a foreign body passes through the lid to lodge in the orbit or in the globe. Thorough inspection should be made of the inner surface of the lid, the conjunctiva and the globe for evidence of penetration. In such a case an x-ray examination should be made to localize the foreign body before an attempt is made to extract it. A wound of this sort should not be probed until one is sure that it does not penetrate the globe. If the globe has been involved, the patient should be hospitalized under the care of an ophthalmic surgeon immediately.

*Foreign Bodies of the Conjunctiva.* Foreign bodies which get onto the con-

junctiva most frequently lodge in the subtarsal sulcus of the upper lid (just behind the margin of the lid). In this position they scratch the globe with each motion of the lid, and if they happen to lie over the cornea, they may produce considerable damage. Another frequent location is in the fornices. There, foreign bodies may cause little irritation with few or no symptoms until they are dislodged or until conjunctivitis occurs as a result of infection introduced with the foreign body. There are numerous authenticated cases of foreign bodies having remained in the fornices for several weeks or even months before they were removed. On the other hand, loose particles in the conjunctival sac usually find their way over toward the caruncle or inner canthus of the eye.

The conjunctiva of the lower lid, lower fornix and lower part of the globe may be exposed for inspection and removal of foreign bodies by everting the lower lid while the patient looks upward. The thumb or index finger of the surgeon's left hand is placed gently on the lower lid close to the lid margin. The lid is then pulled downward and outward as the patient is directed to look upward.

The tarsal conjunctiva of the upper lid is exposed by eversion of the lid. The surgeon grasps the lashes of the upper lid between the thumb and index finger of his left hand and directs the patient to look downward toward his toes (Fig. 329*A*). The surgeon lifts the lid outward from the globe by his grasp on the lashes, then makes pressure downward and toward the globe at the upper border of the tarsus of the lid with the end of an applicator held in his right hand (Fig. 239*B*), and at that same moment pulls the lashes upward and backward toward the patient's brow. Once the lid has been turned the applicator stick is slipped out of the fold and the lid is held in place by pressing the lashes against the brow (Fig. 239*C*). As long as the patient keeps looking downward, the lid is easily controlled.

In order to expose the conjunctiva of the upper fornix, the lid must be doubly everted. The procedure for accomplishing this is the same as described above except that, instead of an applicator, the edge of the blade of a Walker or Fox double everter is placed at the upper edge of the tarsus, the lid is then rolled back onto the blade of the double everter, and the fornix is exposed by exerting gentle pressure downward and outward (away from the globe) on the instrument. The patient must keep looking downward during this procedure also.

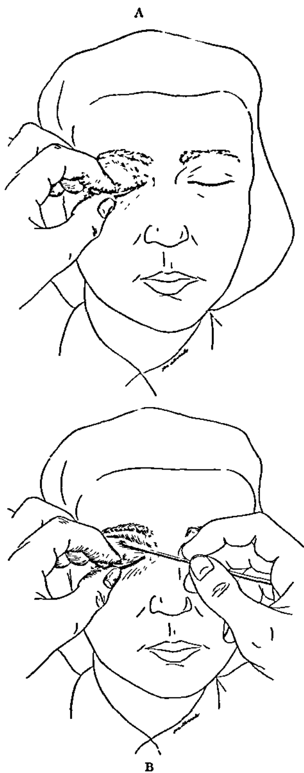
Loose or slightly embedded foreign bodies of the conjunctiva may be removed without anesthesia with a small applicator tightly wound with a wisp of sterile cotton. If a particle is too tightly embedded for this procedure, the conjunctiva should be anesthetized by instillation of a topical anesthetic (5 per cent cocaine, 0.5 per cent Pontocaine, 1 per cent Holocaine, etc.). One drop is instilled onto the conjunctiva every minute for 3 to 5 minutes. The eyes should be kept closed between drops. The foreign body, if small, may be lifted out of the conjunctiva with the point of a sharp, thin-bladed knife such as a cataract knife. A chalazion curet is sometimes useful with larger particles, and rarely conjunctival forceps may be required.

The surgeon should always remember that frequently more than one foreign body is present. He should always search the entire conjunctiva and should avoid use of anesthesia if possible until all foreign bodies are located.

Some foreign bodies, notably glass, plastic material, sand, etc., are difficult to see. If inspection alone does not reveal the foreign body, scratches on the cornea may indicate the position of the foreign body on the lid. These scratches are more easily seen after instillation of a stain, such as fluorescein. One drop of a 1 per cent aqueous solution of fluorescein is instilled into the conjunctiva and the excess washed out with sterile saline. Scratches on the cornea will take a bright green stain. Injuries of the conjunctiva usually take a yellow color with this stain. This, together with the tendency

of the light greenish yellow fluid to puddle around a foreign body, may help to localize a transparent particle.

Inasmuch as many foreign bodies are contaminated by bacteria which are potentially pathogenic for the conjunctiva or cornea, the patient should be given a mild nonirritating antiseptic to use on the conjunctiva for at least 48 hours after removal of the foreign body. For this purpose a 1:5000 aqueous solution of oxycyanide of mercury or a 1:5000 aqueous solution of phenylmercuric nitrate or a 15 per cent solution of sulfacetamide may be used four to six times a day. It is especially important to treat infections of the conjunctiva if they exist, for minor scratches of the cornea produced by a foreign body might lead to a serious corneal ulcer. Therefore, if



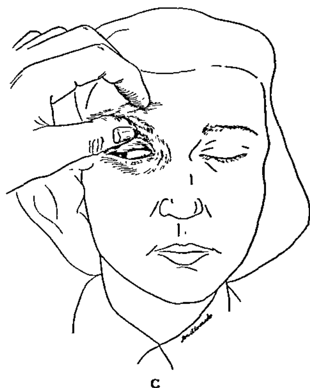




*Figure 329.* Eversion of upper lid. *A*, Lashes grasped and lid pulled outward from globe. *B*, Applicator placed at upper border of tarsus. *C*, Eversion completed and held in position with thumb.

purulent discharge is present at the time of the examination and removal of the foreign body, or if the nasolacrimal passages are obstructed, it would be better to make a bacteriologic examination of the conjunctiva by culture and secretion smears before any medication is used on the conjunctiva. If there is apparent infection on the conjunctiva or obstruction of the nasolacrimal passages, one of the above conjunctival antiseptics should be prescribed for use every hour while the patient is awake Then, depending upon the results of the bacteriologic examination, more specific antibiotic therapy may be employed Eyes should not be covered in the presence of infection.

***Foreign Bodies of the Cornea.*** Any injury of the cornea that extends beneath the epithelium and Bowman's membrane (47 to 74 $\mu$) results in scarring and opacity of the cornea Thus it is important in removal of a foreign body of the cornea to avoid causing additional injury. For that reason it is essential to use magnification both in localizing and in removing foreign bodies Ophthalmologists increasingly are using the corneal biomicroscope in diagnosis and treatment of corneal lesions.

Combining the thin beam of the slit lamp with the magnification of the biomicroscope, the surgeon can judge quite accurately the depth of the foreign body in the corneal tissue. This is important, for those particles that lie deep in the cornea, either near the posterior surface or actually perforating the anterior chamber, should be treated as intraocular foreign bodies because of the danger of dislodging the particle into the anterior chamber of the eye with such possible complications as development of cataract or intraocular infection.

Superficial foreign bodies of the cornea usually consist of small particles with slight momentum such as cinders, pieces of rust, small fragments of glass or plastic material, small flakes of metal, etc. Once the foreign body is localized, the cornea is anesthetized. One drop of a local anesthetic is instilled onto the cornea every 1 to 2 minutes for five times. The eye is kept closed between drops. The patient is placed before a slit lamp and corneal biomicroscope with his head fixed in the head and chin rest. The surgeon adjusts the light and microscope and locates the foreign body. He turns from the microscope, takes a sharp-pointed thin knife in one hand, braces his hand and arm so that his wrist and fingers are freely movable with the point of the knife held close to and in front of the cornea. He then locates the point of the knife through the binocular microscope and moves it to the foreign body, slipping the point alongside the particle and lifting it out of the cornea. During this procedure, one hand is left free to keep the slit lamp and microscope in proper focus

If it is impossible to use the foregoing procedure, after the cornea is anesthetized the patient is placed in a supine position on a treatment or operating table with strong focal illumination of the cornea. Using a loupe or any other device that gives maximum magnification and binocular vision, the foreign body is lifted out of the cornea with a thin, sharp-pointed knife.

During either procedure, it is essential that the patient hold his eye steady. Most patients are sufficiently cooperative to do this if they are told to look at a definite fixed point all the time during the procedure. However, in some cases, especially in children, it will be necessary to use a general anesthetic and hold the globe steady with fixation forceps.

If the foreign body has been present for only a short time, simple removal will suffice; however, when certain types of material have been embedded for more than a few hours, an oxidation or "rust" ring will have formed in the tissues adjacent to the foreign body and will remain after removal of the foreign body. If this ring is allowed to remain, it frequently produces continued irritation or subsequent ulceration at that site. Therefore, it must be removed. A small sterile dental burr carefully placed in the wound and twisted several times will remove the ring with less trauma than most other instruments.

Immediately after the operative procedure, one drop of 5 per cent homatro-

pine should be instilled onto the cornea to control irritation of the iris that invariably is associated with corneal lesions.

After the local anesthesia wears off, the sensation of scratchiness returns until the cornea is healed. Considerable pain may develop with motion of the lids over the raw wound; for this reason, in most cases, the lids are closed and a dressing is placed on the eye until the lesion has healed. However, after removal of tiny superficial foreign bodies, this may not be necessary. In either case, ointments should not be used because of their tendency to interfere with firm, rapid epithelial healing. For the same reasons local anesthetics should not be prescribed for use by the patient. If pain is great enough to require treatment, sedatives or analgesics should be administered by mouth.

The same procedures and recommendations hold for more deeply placed corneal foreign bodies, but those lying close to the posterior surface of the cornea must be removed with extreme care to avoid penetration into the anterior chamber of the eye. If there is little likelihood that the particle can be removed without this complication, or if the object, although stuck in the deep layer of the cornea, actually protrudes into the anterior chamber, the problem should be considered the same as an intraocular foreign body. In these cases it may be necessary to make a small incision through the cornea at the limbus and pass a spatula into the anterior chamber to protect the iris and lens while the foreign body is being extracted. Thus the problem falls in the province of the ophthalmic surgeon skilled in intraocular techniques.

In some cases the foreign body penetrates the cornea at an angle, leaving a slanting track. The best technique for removal then consists in passing a fine sharp knife, such as a needle knife, along the track until the tip of the knife touches the foreign body and the overlying cornea is incised outwardly. The tip of the knife is reinserted alongside the foreign body, which is then lifted out of the wound.

Forceps are never used for removal of fine or embedded foreign bodies of the cornea because they produce too much damage to the cornea and they increase the danger of pushing the object deeper into the cornea or into the anterior chamber. Blunt probes or gouges are not used for the same reasons. Cotton applicators are not used for removal of even superficial foreign bodies of the cornea because of the extensive damage they produce to the delicate epithelium, especially after use of a local anesthetic.

***Foreign Bodies of the Sclera.*** In general, foreign bodies of the sclera consist of the same type of material traveling at approximately the same momentum as those that affect the cornea. Since the sclera is opaque, minor scarring resulting from the trauma does not have the serious consequences that it has on the cornea. Nevertheless, the same general principles and methods should be employed since extensive scarring of the sclera may produce distortion of the globe, thus interfering with vision; and penetrating wounds of the sclera may result in damage or infection of the intraocular structures leading to loss of visual function or loss of the eye.

If the foreign body cannot be seen by inspection of the sclera, the problem should be handled and treated as an intraocular foreign body.

***Intraocular Foreign Bodies.*** Intraocular foreign bodies most frequently consist of metal, although glass, wood, stone and other materials occasionally penetrate the globe. In most cases the particles are traveling with considerable velocity and produce extensive damage to the eye. The eye usually is soft owing to the reduced intraocular pressure, but this depends upon the size and speed of entry of the foreign body. Very small or needlelike particles traveling at high speed may produce such a small wound that the intraocular pressure is not greatly affected. However, with larger wounds intraocular pressure is reduced by loss of part or all of the contents of the

globe. With wounds of the cornea, the aqueous is lost. The anterior chamber of the eye appears shallow or absent, with the iris lying in contact with the posterior surface of the cornea. Frequently the iris will be incarcerated in or prolapsed through the corneal wound. Lens material may be prolapsed into the wound, or at times the lens may be completely extruded and vitreous (a clear, jelly-like material) or a combination of vitreous and blood may fill the wound. When the site of entry lies in the sclera, ciliary body or choroid and vitreous frequently prolapse through the wound. Even if these complications have not occurred as a result of the injury, they may develop as the result of rough handling of the eye or as a result of improper transportation of the patient. Therefore, in order to prevent further damage, the following general principles should be observed in all cases of mechanical injury to the eyeball either with or without an intraocular foreign body:

1. The patient should be placed in a supine position, at least until the extent of the damage can be assessed.

2. The patient should be instructed and impressed with the importance of not squeezing his lids together, as this exerts pressure on the eyeball and may result in further damage by causing extrusion or loss of the contents of the globe.

3. If it is necessary to remove dirt or foreign material from the lids, this should be performed gently without exerting pressure on the globe.

4. The eye should be examined carefully and gently, care being taken to avoid pressure on the globe As soon as it is determined that the patient has sustained a penetrating wound of the globe, the examination should cease. A light dressing should be applied to both eyes and the patient should be transported to the ophthalmic surgeon in a supine or at least a semirecumbent position. By all means he should be prevented from straining, leaning or stooping over, and lying face down. Many cases of relatively minor injury to the globe have resulted in extensive visual loss and even loss of the eye because of failure to observe these precautions.

5. The patient should not be allowed to remove any of his clothing. If necessary, it should be done for him.

6. Local medications should not be used until the patient is seen by the ophthalmic surgeon. It is especially important not to use ointments on the lids or in the eye.

7. No drug should be administered that is likely to produce vomiting. Morphine especially should be avoided for this reason. Codeine, which is less likely to cause nausea, will control pain sufficiently.

8. Clots on the eyeball or prolapsed material in or on it should not be disturbed until seen by the ophthalmic surgeon.

### BURNS OF THE EYE AND ADNEXA

Burns of the lids and eye may be thermal, chemical or irradiational.

#### Thermal Burns

Thermal burns consist of flame burns, explosive burns and burns caused by hot metals, hot liquids, etc. Very frequently these injuries are limited to the lids because of the rapidity of the blink reflex. However, in all cases the conjunctiva and globe should be inspected carefully for evidence of burn and foreign matter.

Minor burns of the lids or even extensive first degree burns of the lids, uncomplicated by injury to the conjunctiva or globe, may be treated by application of a light petrolatum gauze dressing after the lids have been completely closed. The dressing should be left in place for 48 to 72 hours. Thereafter, the dressing may be left off, but the lids should be kept covered with a thin layer of a mild antiseptic ointment, such as a 1 3000 bichloride of mercury ointment.

Second and third degree burns of the lids usually are associated with extensive severe burns of the face and body. Under these circumstances the patient is likely to be suffering from shock. Therefore, the primary consideration is to begin treatment of this serious complication.

Once this has been initiated, the surgeon may turn his attention to definitive treatment of the burn. So far as the eyes are concerned, the lids, conjunctiva and globe should be inspected carefully to determine the full extent of the injury. Superficial debris and foreign material on the lids, conjunctiva and cornea should be removed gently. If the conjunctiva and cornea have not been damaged, the lids may be closed after instillation of a mild antiseptic ointment into the conjunctival sac. The lids should be closed either by carefully dressing the eye or by suture. For this purpose a double-armed 0000 black silk suture is used. The needles are placed through the holes of a small pearl button or through a rubber peg, then passed into the lid approximately 3 mm. from the lid margin, then passed down through the substance of the lid to emerge from the lid in the posterior third of the intermarginal space. The needles are then inserted in a corresponding point of the intermarginal space of the opposite lid and passed through the substance of the lid to merge from the anterior surface of the lid approximately 3 mm. from the margin The needles are passed through the holes of a small pearl button or through a rubber peg and the sutures are tied so as to bring the lid margins into apposition. Two of these mattress type sutures should be used, one at the junction of the middle and outer thirds of the lid, and one at the junction of the middle and inner thirds of the lid. The burned surfaces of the lids may be covered with two or three layers of sterile petrolatum gauze and a moderate pressure dressing is applied.* These dressings may be changed as necessary until the lids have healed. Then the lid sutures may be removed. If contractures develop, they should be corrected by removal of scar tissue and skin grafting However, maintenance of approximation of the lid margins during healing prevents a considerable amount of shortening of the lids.

If, on the other hand, there should be involvement of the conjunctiva and globe, definitive ophthalmic care should be instituted at once before the lids are closed.

Burns by hot metals include molten lead, molten iron, glowing metallic sparks, molten solder and other alloys, hot cinders, etc. The burns produced from molten solder and similar alloys ordinarily are not as extensive as those produced by molten iron, steel, brass and slag because the former cool more rapidly. However, in either case extensive damage may be produced to ocular tissues, depending upon the degree of trauma and the position of the burn. Hot metallic sparks and cinders may be removed from the tissues of the lid, conjunctiva and sclera, the adjacent burned tissue removed, and the wound closed, provided the burn is not too extensive. With more extensive burns of the lids and conjunctiva the defect will have to be closed by skin or mucous membrane graft. Penetration of the globe by a tiny piece or drop of hot metal does not necessarily mean loss of the globe, but this type of injury will have to be treated as an intraocular foreign body. Large burns of the globe with or without penetration should be treated as serious ocular injuries, as they frequently tend to become infected. Secondary infection, therefore, should be kept in mind and prophylaxis instituted. In the more extensive injuries one of the sulfa drugs, streptomycin or chloramphenicol should be given by oral or intramuscular routes.

### Chemical Burns

Chemical burns of the eye are increasing in frequency both in the home and in industry as the result of our rapidly expanding technical developments. The severity of a chemical burn depends upon many factors such as the chemical nature of the substance, its rate of absorption into tissue, the quantity available for absorption and the duration of contact. Depending upon its nature, the chemical may destroy or injure tissue by denaturing proteins, altering mucopolysaccharides, dissolving lipids, inactivating enzyme systems or disrupting cells by its

* Tannic acid and paraffin sprays are contraindicated for lids.

physical action on surface tension. Some of these effects are produced by the extreme acidity or alkalinity of the substance, some by direct chemical union, and some by physicochemical reactions. The quantity available and rate of absorption depend to a certain extent upon the physical state of the chemical at the time of its contact with the tissues, i.e., whether gaseous, liquid or solid.

The local effect of gases or vapors upon the eye varies with the nature of the chemical, its concentration and the duration of exposure. In mild exposure to irritating gases burning and smarting of the eyes occur, with redness of the conjunctiva If the corneal epithelium is examined under strong magnification and illumination, such as the slit lamp and corneal biomicroscope, superficial, small, grayish-white opacities representing tiny areas of epithelial edema and erosion will be found. With stronger concentrations or longer exposure, variations of increasing damage up to and including necrosis of the epithelium and stroma will be found.

Solids include fumes, dusts and larger particles. In order to produce injury other than mechanical damage as foreign bodies, these substances must be soluble; therefore, they may be considered along with liquids.

In the home, as well as in industry, a large number of chemicals have found increasing use. However, from the standpoint of the physiologic response they produce, they may be classified roughly as acids, alkalies and detergents (solvents) Depending upon the quantity of the agent, the duration of exposure and the idiosyncrasy of the patient, they produce an inflammatory reaction characterized by irritation of the eyes, lacrimation, blepharospasm and photophobia. The destruction may vary from slight epithelial damage to extensive necrosis.

*Acid Burns.* The mineral acids such as sulfuric, nitric and hydrochloric, mixtures such as aqua regia, and organic acids such as acetic acid are used widely in industry, research laboratories, and the home. Thus frequent accidents result from one of these agents being splashed into the eye.

As a rule, acid burns are instantaneous, consisting of precipitation and denaturation of tissue proteins. The extent of the burn depends upon the concentration of the acid, the amount of dissociation, the character of the union and the duration of exposure to the tissue before dilution and removal. As a rule, acid burns are not progressive and heal more rapidly than alkali burns.

Immediate treatment of acid and other chemical burns of the eye should be by copious washing of the eye with water. Tap water is quite satisfactory for this purpose. The face and lids should be washed off quickly by thoroughly flooding the face with water. The lids should be held open while the conjunctiva then is flooded gently but copiously. When one eye is affected, the blepharospasm can usually be overcome if the lids of both eyes are held open. Washing of the eyes should be continued for approximately 5 minutes before the patient is taken to a dispensary or a physician If the physician is called to the scene of the accident, he should instruct the person calling to continue gentle bathing of the eye with water until he arrives.

When the physician sees the patient, he should determine the nature and type of injury. But while obtaining this information, he should place the patient in a reclining or supine position, and he should then examine the lids, conjunctiva and cornea with magnification and strong focal illumination for foreign bodies. If any are found, they should be removed as described under *Foreign Bodies,* except that if solid particles of the chemical are present, they may be removed by loosening them and lifting them out or by washing them out. After this has been completed, a drop or two of 1 per cent Holocaine or 0 5 per cent Pontocaine may be instilled. Then the eye should be irrigated gently but continuously for 15 to 30 minutes, depending upon the quantity of the chemical or the severity of the burn. For this period of irrigation, normal saline or a neutral

buffer solution should be used if available, but tap water should be used rather than waiting for preparation of a solution.

At the termination of the irrigation, one drop of a 1 per cent aqueous solution of fluorescein should be placed on the conjunctiva and the excess washed out. Damaged epithelium of the cornea will take a green stain and damaged epithelium of the conjunctiva will take a pale greenish yellow stain.

For milder and superficial burns, the patient need not be hospitalized. One drop of 5 per cent homatropine or 0.2 per cent scopolamine should be instilled into the eye immediately to relieve the iris irritation and photophobia. Dark glasses should be ordered and the patient given a mild conjunctival antiseptic solution with instructions to instill one drop into the eye every 2 hours. Local anesthetics should not be prescribed. If pain is sufficient to warrant treatment, codeine should be prescribed for oral use. The patient should be seen once or twice daily thereafter until the lesion has healed.

Patients with extensive burns of the conjunctiva and opposing raw surfaces or with extensive burns of the cornea or a combination of the two, should be admitted to a hospital for definitive care, because of the danger of the development of extensive adhesions between the lid and globe (symblepharon) and because of the danger of severe intraocular inflammation, which frequently is complicated by secondary glaucoma. In these cases the ophthalmic surgeon must decide between conservative immediate treatment and late plastic repair or immediate débridement and mucous membrane grafting.

*Alkali Burns.* In addition to the widespread use of lye and other alkalis as cleaning agents, which are accidentally splashed into the face and eyes, there have been an increasing number of injuries resulting from the vicious use of the "lye cocktail"—a solution of lye, frequently hot, thrown into the face of a person. Lime solutions and lime dust also produce severe alkali burns.

Alkali combines with protein and fat to form alkaline proteinates and soap, both of which are soluble and penetrate deeply into the tissues of the eye. As a result of the penetration and continued alkaline action, the damage is increased. Scarring increases, and the eye remains red and irritable. The extensively burned eye, even after the prolonged and slow healing period, remains more easily irritated by minor trauma. The tissues frequently break down, with the formation of corneal ulcers commonly followed by iridocyclitis and glaucoma.

The immediate treatment for alkali burns is copious irrigation of the face and eyes with water. The most readily available source of water should be used. The face and lids should be washed rapidly with a large amount of water; then the lids should be held open while a continuous gentle flow of water is allowed to run over the conjunctiva, cornea and lids. The lids should be moved from time to time, and the patient should be made to move his eyes up and down and from side to side while the water is running in order to expose the entire surface of the eyes and lids. If solid particles of alkali are adherent to the conjunctiva, they should be loosened and flushed out during the irrigation. The irrigation should continue until the physician arrives or for a minimum of 15 minutes before the patient is taken to a dispensary.

Upon arrival, the physician should reexamine the lids, conjunctiva and cornea for solid particles of alkali and remove them. Irrigation should be continued for at least another 30 minutes. Water should be used until saline or a neutral buffer solution is available. If the pain is severe, 1 per cent Holocaine or 0.5 per cent Pontocaine may be installed once or twice. If the blepharospasm is severe and is not controlled by the local anesthetic, akinesia of the lids may be obtained by the injection of 1 cc. of Novocain into the seventh nerve just anterior to the ear as it crosses the ramus of the mandible.

Inasmuch as alkali burns are severe and progressive, the patient should be

hospitalized immediately after irrigation and placed under the care of an ophthalmic surgeon even if it means transportation for some distance.

*Lime Burns.* Lime burns frequently result from lime dust or mortar being blown or accidentally thrown into the face and eyes. These injuries are essentially alkali burns but small particles of lime tend to cling to the conjunctiva. The immediate treatment should be rapid washing of the face and lids and irrigation of the eyes with water. However, after a minute or two the irrigation should be interrupted and the particles of lime removed from the conjunctiva. During this initial treatment an assistant should be preparing a fresh aqueous solution either of 3 per cent sodium bicarbonate or 2 per cent neutral ammonium tartrate for continued irrigation of the eyes for at least 30 minutes. However, should there be any delay in preparation of either solution, irrigation should be continued with water. Further treatment is the same as for other alkali burns

***Detergents and Solvents.*** The increasing use of synthetic detergents in the home in place of soaps and the increasing use of detergents and other solvents in industry have increased the incidence of accidents resulting from splashing these substances into the face and eyes. Many of these substances have little local effect upon the skin of the hands, although high concentrations may result in their absorption with general toxic effects. Relatively low concentrations may produce irritation of the eye, and strong concentrations may result in extensive epithelial damage.

The mild local effects on the eye consist of a burning sensation, mild photophobia, redness, lacrimation and frequently blurring of vision. Examination of the cornea reveals punctate epithelial erosions The erosions may be multiple, and in more severe lesions large portions of the cornea may be denuded.

Immediate treatment for accidental splashing of the eye with a detergent or solvent is, again, copious washing of the lids and eye with water. However, because of the ready solubility of these compounds, 5 minutes of constant irrigation should be sufficient before the patient is taken to the physician.

Upon arrival, the physician should examine the globe under magnification and strong illumination, and after application of fluorescein stain, he should irrigate the eye for another 5 to 10 minutes, then restain and examine. For milder burns, one drop of 5 per cent homatropine or 0.2 per cent scopolamine should be instilled and a mild conjunctival antiseptic solution prescribed for use every 2 hours while the patient is awake. The patient should be given dark glasses and should be seen daily until the lesion is healed. Patients with more severe burns should be hospitalized.

### *Burns Caused by Gases*

***Tear Gas.*** After mild exposure to tear gas, increased lacrimation, redness of the eyes and a scratchy sensation diminish and disappear within an hour. However, with greater exposure these symptoms are prolonged and accompanied by epithelial erosion. Severe exposure results in deep ulceration and opacification of the cornea as well as scarring of the conjunctiva. Immediately after exposure the eyes and lids should be bathed with large quantities of water. Then sodium sulfite (0.4 per cent) in a vehicle composed of 75 per cent glycerin and 25 per cent water should be instilled at frequent intervals into the conjunctival sacs. The eyes should not be dressed and the lids should be lifted away from the globes several times a day to prevent adhesions. For burns of the skin of the lids and face, gentle application of 4 per cent solution of sodium sulfite in 50 per cent alcohol is effective This solution must not be allowed to reach the conjunctiva or cornea.

***Sulfur Dioxide.*** Sulfur dioxide has been used extensively as a refrigerant gas, but because of the severity of the ocular burns it produces it is being replaced by less toxic refrigerant gases. Immediately after accidental exposure to sulfur dioxide gas the eyes are irritated for a few minutes but the symptoms di-

minish and the victim may think that his injury was insignificant. However, after several hours lacrimation and redness of the eyes return, accompanied by blurred vision, pain and photophobia. This marks the onset of a severe and progressive burn which may result in loss of the eye. Therefore, even though the injury may seem insignificant, treatment should be given immediately. Copious bathing of the eye with water is the first step. This should be followed by instillation of a 0.4 per cent solution of sodium bicarbonate in a vehicle composed of 75 per cent glycerin and 25 per cent water. To control iris irritation and photophobia one drop of 0.2 per cent aqueous solution of scopolamine should be instilled on the cornea three times a day.

Many commercial refrigerating systems use ammonia gas. Injuries to the eyes with this gas should be treated as alkali burns.

*Mustard Gas.* Exposure of the eye to mustard gas produces rapid irritation with blepharospasm and swelling of the lids. Often the blepharospasm is increased by the victim's fear of being blinded. Part of this may be overcome by opening the lids to assure him that he can see. The eyes should be irrigated as quickly as possible with a 1.5 per cent aqueous solution of sodium bicarbonate. This should be accomplished with a large quantity of solution flowing continuously over the eyes while the lids are held open. After 2 minutes the irrigation should be stopped and the conjunctival sac filled with a 5 per cent solution of BAL (2,3-dimercaptopropanol) in ethylene glycol or an appropriate ointment base. After 10 minutes one drop of a 0.2 per cent aqueous solution of scopolamine should be instilled onto the cornea. This should be repeated three times a day until the lesion has healed. Dressings should not be used.

*Lewisite.* Severe immediate irritation and blepharospasm are produced by exposure of the eye to liquid or gaseous lewisite. Injury is produced much more rapidly than with mustard gas. British antilewisite (BAL) should be instilled immediately. A single instillation of 0.1 cc. of a 5 per cent solution of BAL in ethylene glycol or an appropriate ointment base may afford complete protection if applied within 2 minutes after exposure. A delay of 5 minutes usually results in some corneal opacification, and treatment after a longer interval is much less effective. The antidote itself is irritating to the eye but does not produce permanent damage.

*Nitrogen Mustards.* The general toxicity of the nitrogen mustards for ocular tissue is similar to that of mustard gas although they differ among themselves in speed of reactivity. Treatment should be the same as for mustard gas burns; however, BAL is not as effective against any of the mustard gases as against lewisite.

### Irradiation Burns

*Ultraviolet Light.* Exposure of the eye to ultraviolet light may result in a burn of the cornea. The interval between exposure and development of symptoms varies with the duration and intensity of the exposure, but is from 4 to 12 hours on the average. Burns of this type may result from exposure of the eye, without protective glasses or masks, to ultraviolet rays from "sun" lamps, carbon arcs, welders' arcs and prolonged exposure to sunlight on beaches or in snow fields (snow blindness). The early manifestations are a scratchy sensation of the eyes and lids associated with increased lacrimation. These symptoms are quickly followed by photophobia, which becomes intense and is accompanied by blepharospasm. Examination of the eyes is difficult because of these two symptoms. However, photophobia and blepharospasm may be relieved rapidly by instillation of one drop of a 5 per cent aqueous solution of cocaine followed in 2 minutes by one drop of 10 per cent solution of Neo-Synephrine and, 2 minutes later, by one drop of 5 per cent aqueous solution of homatropine. Once the photophobia is controlled, the patient is relieved and healing occurs within 12 to 24 hours.

*Roentgen Ray and Radium.* Roentgen ray and radium burns of the lids and eyes do not develop for several weeks

hospitalized immediately after irrigation and placed under the care of an ophthalmic surgeon even if it means transportation for some distance.

*Lime Burns* Lime burns frequently result from lime dust or mortar being blown or accidentally thrown into the face and eyes. These injuries are essentially alkali burns but small particles of lime tend to cling to the conjunctiva. The immediate treatment should be rapid washing of the face and lids and irrigation of the eyes with water. However, after a minute or two the irrigation should be interrupted and the particles of lime removed from the conjunctiva. During this initial treatment an assistant should be preparing a fresh aqueous solution either of 3 per cent sodium bicarbonate or 2 per cent neutral ammonium tartrate for continued irrigation of the eyes for at least 30 minutes. However, should there be any delay in preparation of either solution, irrigation should be continued with water. Further treatment is the same as for other alkali burns.

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cornea has become vascularized, the transplant is likely to become opaque after the operation, with failure to achieve the end for which it was performed.

### WOUNDS AND LACERATIONS OF THE LIDS

Wounds and lacerations of the lids vary greatly in extent and severity but even minor wounds may result in considerable functional impairment and disfiguring scars if improperly handled. Wounds at or near the inner canthus may sever the canaliculi or result in cicatricial occlusion of the puncta and canaliculi, in this way interrupting the flow of tears and causing epiphora. Wounds involving either canthal ligament, unless properly repaired, will result in distortion of the palpebral fissure and disfigurement. Wounds through the lid margin, unless accurately approximated, will result in a notch defect at the margin, and even simple wounds of the skin surface of the lids may result in ectropion and distortion of the lids from contracting scar tissue. Since the lids are important components of a person's facial features, even minor defects are noticeable and cause much anguish. Every effort should be made to obtain adequate primary repair of wounds and lacerations of the lids. Much can be done to improve poor results by secondary plastic repair, but in the majority of cases these procedures may be avoided by adequate initial repair.

Wounds and lacerations of the lids frequently occur in conjunction with extensive injuries of the head and body and may be accompanied by shock. In such cases treatment for shock should be initiated immediately, and as it is being brought under control, the extent of injury may be determined and the further course of action outlined. Lifesaving measures naturally take precedence, but the sooner the ocular injuries are treated the better the results. Immunization therapy against tetanus and gas gangrene should be used in cases of lacerations of the eye and adnexa. In any laceration of the lids, the wound should be thoroughly cleansed and any foreign particles removed. Most foreign matter may be removed by gentle irrigation of the wound with warm sterile saline solution. Occasionally particles may have to be picked out. However, débridement is rarely necessary and should be avoided. In those rare cases in which it is necessary, immediate primary plastic repair is indicated rather than simple closure of the defect. Fragments of tissue almost completely or completely severed frequently may be replaced in the defect and used as "free grafts" after they have been cleansed. Bleeding should be controlled before lid wounds are closed. Pressure alone will control the majority of bleeding points, which is fortunate, for the less suture material buried in the lids the better the final result.

Superficial lacerations of the skin surface of the lids may be closed by simple approximating sutures. For linear wounds, closure with a continuous subcuticular 0000 braided black silk suture is most satisfactory. If this suture is placed so that accurate approximation of the skin edges is obtained, minimal cicatrization results. The suture should be left in place for 7 to 8 days. Ragged and irregular wounds should be accurately approximated and then closed with interrupted sutures placed superficially in the skin. For this purpose 000000 black silk should be employed, and the sutures may be removed in 48 to 72 hours. Small wounds of this type need not be dressed but should be kept covered with a small amount of antiseptic ointment (1:3000 bichloride of mercury). In more extensive wounds, after repair, the lids should be closed and covered with a thin layer of sterile petrolatum gauze and a pressure dressing applied for 48 hours. Thereafter, a light dressing may be substituted or the dressing left off.

Wounds involving the entire thickness of the lid necessitate careful examination in order to determine whether the globe and orbital structures have been involved. Such injuries, if found, should be repaired before closure of the lid

after treatment with these agents. Burns of the skin of the lids are similar to cutaneous burns elsewhere on the body, except that the skin of the lids is somewhat more susceptible. Excessive irradiation of the eyeball may produce uveitis, glaucoma or cataract. Therefore, roentgenologists take special precautions to shield the eyes when using irradiation therapy in the vicinity of the orbits. However, in the treatment of malignant lesions of the eye and orbit it may be necessary to expose the eye to a harmful dose. In these cases the patient should be forewarned of the danger and should be observed by an ophthalmologist, before, during and for several months or even years after treatment.

### Complications of Burns

*Secondary Infections.* After injuries of the eye, secondary infections are frequently serious complications. This is especially true after burns of the conjunctiva and the cornea. Therefore, since dressing an eye tends to increase the possibility of infection and to prevent drainage of secretions from the conjunctival sac, the eye is left open in cases of conjunctival and corneal burns. A nonirritating conjunctival antiseptic solution should be instilled several times a day beginning immediately after the initial treatment has been completed. For this purpose a 1:5000 solution of oxycyanide of mercury or a 1:5000 solution of phenyl mercuric nitrate is preferable to one of the antibiotics. The silver protein solutions should not be used if the cornea is involved. When infection is present, the cause should be determined by examination of stained secretion smears and bacteriologic cultures. Then more specific treatment may be employed.

*Synechiae.* In addition to prevention of secondary infections after burns the surgeon must be alert to prevent development of synechiae between the lids and the globe. Leaving the eye open and frequent separation of the lids from the globe may prevent adhesions in the milder cases. In more severe burns special conformers may be inserted in the conjunctival sac, or in some instances early mucous membrane grafting may be required.

*Pain.* The principal source of pain after a burn is movements of the irritated iris resulting from the reflex to light. This may be eliminated by maintaining cycloplegia with scopolamine or atropine until the lesion has healed. Some additional pain resulting from movement of the lids over the injured cornea and conjunctiva usually is present but may be controlled by mild oral analgesics.

*Corneal Scars.* Corneal scars frequently result from burns. Epithelial lesions of the cornea heal without scarring. However, if the injury is deeper than the epithelium some scarring always occurs. The deeper the lesion or the longer the time required for healing, the more scar is produced. Vascularization of the cornea occurs in many cases, particularly after larger lesions or slowly healing ones. In some cases the scars show a tendency to break down, producing ulcers of a recurring type. When this happens, scarring and vascularization of the cornea increase. However, in the majority of cases the scarring is most intense immediately after the injury has healed and there will be some diminution or clearing of the cornea for as long as a year after the injury. During this period treatment with mild irritants may be of some benefit, although this is questionable. Beta irradiation therapy may be beneficial in reducing vascularization and in increasing the clearing but should be administered only by experts in this form of therapy.

*Corneal Transplants.* Additional restoration of vision may be obtained in properly selected cases by a corneal transplantation operation. However, this operation should not be considered as long as the scar is diminishing or clearing. Only in those cases in which the eye is normal except for the corneal scar is the operation indicated. Even then results are best when the scar is limited to the pupillary portion of the cornea and the cornea is not vascularized. In extensive corneal scarring in which the

that the lid margin is closed accurately. The mattress suture then should be tied snugly but only tightly enough to obtain approximation. The lid should then be everted and the conjunctiva approximated with superficial interrupted 000000 black silk sutures approximately 3 mm. apart. The first suture should be placed just below the lid margin. No suture is required in the intermarginal space. The skin wound should be closed with superficial interrupted 000000 black silk sutures, one of which should be placed just below the lid margin (Fig. 332*F*). The lids should be closed and covered with a thin layer of sterile petrolatum gauze and a pressure dressing should be employed for 48 hours. This should then be changed and replaced, or replaced with a light dressing. The superficial skin sutures may be removed after 48 to 72 hours. The mattress suture should not be removed for 7 days. The conjunctival sutures need not be removed, since they usually fall out after 48 hours.

Treatment of lacerations that involve the lateral canthal ligament must, in addition to the principles discussed, include location and suturing of the ends of the ligament to prevent drooping of the lateral canthus. The ligament should be repaired with a double-armed 0000 catgut suture.

A laceration that involves the medial canthal ligament frequently also involves the nasolacrimal sac or the canaliculi. Therefore, inadequate repair of this type of wound may result in a fistula or stenosis of the lacrimal passages as well as drooping of the medial canthus. The best functional results are obtained in these patients by proper primary care, but even in skillful hands results are not always satisfactory. Therefore, the general physician and surgeon can avoid considerable difficulty for himself and his patient by obtaining competent aid for the immediate repair of this type of injury. The nasolacrimal passages should be examined carefully for evidence of injury. If an injury is not obvious, the passages should be irrigated gently with a 2 per cent aqueous solution of Mercurochrome or a 1 per cent aqueous solution of fluorescein. The colored fluid escaping from the passages into the wound will indicate their involvement.

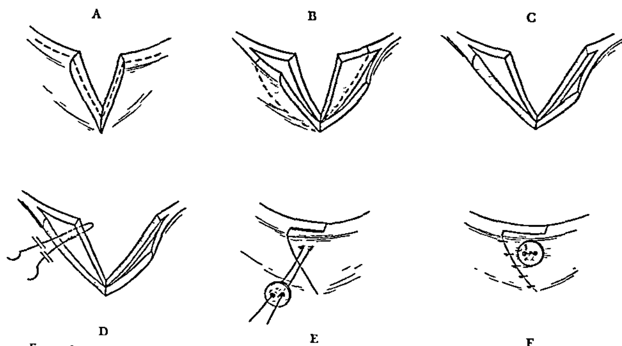



*Figure 332.* Repair of laceration of lid. *A*, Location of line of incision indicated by dotted lines *B*, Wedges of tissue to be removed from the anterior [illegible]

[illegible] by superficial interrupted sutures

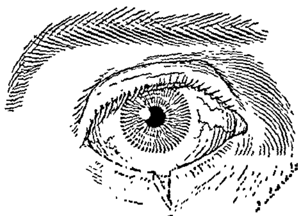


*Figure 330.* Laceration of lower lid.

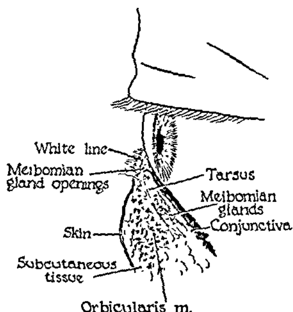



*Figure 331.* Schematic cross section of lower lid showing relationship of the white line to the plane separating the orbicularis muscle and tarsus.

wounds and the possibility of foreign bodies should be considered.

In wounds that involve the entire thickness of the lid but do not extend through the lid margin, the conjunctival defect should be closed first. The lid should be everted and accurate edge-to-edge approximation of the conjunctival wound obtained by superficial interrupted 000000 black silk sutures. The sutures should be placed approximately 3 mm. apart. These sutures seldom need to be removed, since they usually drop out of the conjunctiva after 48 hours. The skin wound should be closed as previously described. It is not necessary to use buried sutures in the lid, as accurate approximation of the tissues combined with accurate closure of the surface wounds and pressure dressing after the lids have been closed and covered with a thin layer of sterile petrolatum gauze will result in good healing. The pressure dressing should not be disturbed for 48 hours, after which it may be replaced by a light dressing.

Lacerations involving the full thickness of the lids including the lid margins (Fig. 330) require special care in closure to avoid notching defects at the lid margins. Simple edge-to-edge approximation seldom prevents this defect. Therefore, immediate plastic repair is preferable. The lids should be split into two layers for 5 to 6 mm. on each side of the wound. The separation should be made in the plane of the white line of the lid margin or just anterior to the tarsus (Figs. 331 and 332*A*). The anterior layer thus is composed of skin, subcutaneous tissue and orbicularis muscle, and the posterior layer is composed of tarsus, glands and conjunctiva. After the splitting procedure the anterior layer of the lid on one side of the wound is removed. The line along which excision is accomplished should begin 3 mm. from the edge of the wound at the lid margin and should end in the tip of the wound away from the lid margin (Fig. 332*B*). In the same manner a similar segment of the posterior layer is removed from the lid on the opposite side of the wound (Fig. 332*C*). A double-armed 0000 black silk suture is placed through the posterior half of the lid margin on the side on which it is longest (Fig. 332*D*). The needles are introduced through the conjunctiva 3 mm. below the lid margin and approximately 2 mm. apart. The lid defect is closed and the lid margins are approximated accurately with forceps until the needles of the mattress suture are brought through the overlapping anterior layer of the lid (Fig. 332*E*). The needles are then passed through the holes of a small pearl button or through a rubber peg and the sutures are tied. A trial tie should be made, and if the wound edges are not properly approximated, the suture should be removed from the anterior flap and replaced so

tinuous subcuticular sutures or with interrupted superficial fine silk sutures.

Ptosis, or drooping of the upper lid, is due to a defect in or paralysis of the levator palpebrae superioris muscle. When congenital, the condition is usually bilateral and often is associated with paralysis of the superior rectus muscle. Occasionally it is associated with paralysis of all the muscles supplied by the third cranial nerve. Congenital ptosis usually is stationary. Acquired ptosis is usually unilateral and may be caused by lesions of the cervical sympathetics or the third cranial nerve, or injuries of the levator palpebrae muscles. Thus, acquired ptosis may be a sign of apical tuberculosis or a tumor of the neck as a part of Horner's syndrome, or a sign of an intracranial lesion. Therefore, a careful examination should be made to determine the cause of the ptosis before treatment is undertaken. After this has been done, care must be used in selection of the operative procedure to be employed, since there often is associated paralysis of other extraocular muscles. The upper lid serves to protect the cornea from drying and injury, especially in sleep; therefore, the corrective procedure must not overcorrect the defect so that the eye cannot roll up under the upper lid. For these reasons, even though the correction is considered minor surgery, the interests of the patient are best served by the ophthalmic surgeon trained in the examining procedures that will permit him to evaluate all the ocular factors and so choose the technique most suitable for the individual patient. The basic principles upon which numerous variations in technique have been devised are: (1) a suspension type of operation, in which the lid is elevated to the desired position by a retained suture (cotton, silk, stainless steel wire or tendon) or by the production of scar tissue; (2) a partial resection (shortening) of the levator palpebrae superioris, thereby increasing the efficiency of its action; or (3) a procedure that connects the lid with the superior rectus muscle, and thus causes the lid to be elevated when the eyeball turns upward.

The rare congenital anomalies of the lids are *ablepharia,* absence of the lids; *ankyloblepharon,* partial or complete adhesion of the lid margins to each other; *blepharophimosis,* a vertical fold of skin in front of the lateral canthus; *cryptophthalmos,* absence of the palpebral fissure, usually accompanied by an underlying rudimentary eyeball; *coloboma,* a notch in the margin of the eyelid; *distichiasis,* presence of two rows of eyelashes, one of which is turned toward the cornea; *ectropion,* outward turning of the margin of the lid; *entropion,* inward turning of the margin of the lid; *epitarsus,* a conjunctival fold running from the fornix to the lid margin; *microblepharia,* small eyelids; and *symblepharon,* an adhesion between the inner surface of the lid and the eyeball.

## TUMORS OF THE LIDS

Almost any type of tumor may be found on or in the lids. Among the more common ones are papillomas, angiomas, nevi, xanthomas, basal cell carcinomas and epitheliomas. The rarer tumors include fibromas, neuromas, adenomas, myomas, chondromas, lymphomas, sarcomas, dermoids, common warts, molluscum contagiosum and melanomas.

Most tumors are observed early because of the attention paid by the patient or his friends to the lids as an important part of his features. Many exist for a long time without change or without the production of symptoms. However, small tumors on the intermarginal space of the lids may cause irritation of the conjunctiva even though the tumor is minute.

In many cases a correct diagnosis is difficult from clinical appearance alone. Therefore, when lid tumors are removed, they should always be examined microscopically, for many insignificant-appearing tumors have proved to be malignant. For that reason and to avoid later disfiguring surgical procedures, any lid tumor of questionable or doubtful characteristics should be removed with a wide border of normal tissue, and the defect should be closed by planned plastic methods. Even then if microscopic ex-

A small plastic tube should then be threaded through the puncta, canaliculus, lacrimal sac and nasolacrimal duct and brought out through the nares and taped or tied in place. This will serve to maintain patency of these passages during healing and prevent stenosis by constricting scar tissue The tube should be left in place for 21 to 30 days. After the tube has been placed, the wound in the lacrimal sac should be closed with the finest plain catgut available (0000 or smaller) If the wound has passed through a canaliculus it should be approximated as accurately as possible, with buried catgut sutures placed around but not anchored to the plastic tubing. The medial canthal ligament should be closed accurately with a 0000 double-armed catgut suture. The remaining tissues should be placed back into proper position and the skin wound closed over them, either with a continuous subcuticular suture or with superficial interrupted sutures. The lids should be closed and covered with a thin layer of petrolatum gauze and a pressure dressing should be employed for 48 hours. Thereafter, a light dressing may be substituted. The superficial sutures may be removed after 48 to 72 hours The plastic tubing should be moved back and forth in the lacrimal passages daily after the pressure dressing has been removed. Some surgeons have made effective use of other materials for maintaining patency of the lacrimal passages.

In extensive lacerations of the lids, whether they be repaired by simple closure or by plastic methods, it is frequently advantageous to maintain closure of the lids during the period of healing by means of lid sutures. The method for this was described in the section on ocular burns. However, the lids should not be closed in this manner if the orbit or globe is injured, at least until definitive ophthalmic care has been instituted.

#### LACERATIONS OF THE CONJUNCTIVA

Lacerations of the conjunctiva seldom occur alone. They usually occur in conjunction with a severe laceration of the lids or as a part of a penetrating wound of the globe. Occasionally a missile or weapon may pierce the conjunctiva without injury to the lids or globe but may produce serious damage to structures in the orbit. If the orbit or globe is involved, the patient should be hospitalized immediately and placed under the care of an ophthalmic surgeon. If the conjunctiva alone is injured, it should be closed with interrupted fine sutures placed about 3 mm. apart. Failure to close gaping conjunctival wounds is likely to result in persistent and annoying granulations arising from subconjunctival tissue. Local anesthesia usually is adequate. One drop of 5 per cent aqueous solution of cocaine is instilled every 2 minutes for 10 minutes. The patient is cautioned to keep his eyes closed between drops In children a short-acting general anesthetic may be required.

#### ANOMALIES OF THE LIDS

Although there are numerous anomalies of the lids only two are common, epicanthus and ptosis.

In epicanthus a fold of skin extends vertically downward from the inner end of the brow to the side of the nose. This condition is always bilateral and, owing to the covering of the medial canthus by the skin fold, the face of the child has an Oriental appearance. Also, because of this fold the cornea appears to be closer to the medial canthus than to the lateral, thus frequently causing parents to think the child is "cross eyed." This may be disproved by observation of the location of the corneal reflexes. When the child looks at a light held in the midline one meter in front of his face, the light reflexes on the two corneas are symmetrically placed if the eyes are straight. If the child actually has crossed eyes the light reflex will be in the center of the pupillary area of one eye but eccentric in the other. As a rule the skin fold gradually disappears but if it is still present at the age of puberty, the child's appearance may be improved by removing the vertical ellipse of the skin from each side of the upper portion of the nose. The wounds should be closed with con-

slower than growth of the main mass. While the tumor is small, it may be excised along with a wide rim of normal conjunctiva at the base. The sclera should be cleaned thoroughly of all subconjunctival tissue and the surface of the sclera cauterized superficially with an electrocautery or an actual cautery. The conjunctiva should not be closed over this defect. A mydriatic (0.2 per cent scopolamine or 1 per cent atropine) should be instilled onto the cornea and the eye dressed. The dressing should be changed and a mydriatic instilled daily until the conjunctiva has proliferated over the defect. The patient should then be observed at regular intervals to be sure that the tumor does not recur. Recurrences, if observed early, may be treated in the same manner. However, if there is evidence of scleral involvement, the eye should be removed.

*Malignant melanoma* of the conjunctiva usually occurs at the limbus as a rapidly growing nonpigmented (fleshy) or pigmented diffusely infiltrating tumor. It usually occurs in middle or older age groups. The only treatment is removal of the eye along with a wide margin of healthy conjunctiva around the tumor.

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amination reveals that the tumor was not completely removed, further excision and repair should be accomplished as soon as possible.

Irradiation therapy is beneficial and effective in the control of basal cell carcinoma on the skin of the lid, but the eyeball must be carefully protected to prevent development of uveitis, glaucoma and cataract. Because of this and because of the appearance of the skin of the lids after irradiation therapy, surgical excision with plastic repair is still the treatment of choice in the majority of cases, especially in the early cases. On the other hand, irradiation therapy may be quite useful in extensive lesions, in cases of lymphoma and in large angiomas as a preliminary to surgical excision.

### TUMORS OF THE CONJUNCTIVA

The common growths of the conjunctiva are dermoid, lipoma, nevus, pingueculum, pterygium, epithelioma and melanoma.

*Dermoid tumor* of the conjunctiva is a small, pink, round, congenital growth situated at or near the limbus. Occasionally hairs protrude from the surface. Excision of the tumor with closure of the conjunctiva over the raw surface produces a cure.

*Lipoma* of the conjunctiva is a subconjunctival fatty tumor usually occurring on the temporal side of the globe. Microscopic examination may show the mass to be a pure lipoma or a dermoid predominantly composed of fatty tissue. Simple excision followed by closure of the conjunctiva effects a cure.

*Nevus* of the conjunctiva is similar to a pigmented mole elsewhere on the body. It should not be disturbed unless there is evidence of malignant change. Some pathologists do not believe that this occurs.

*Pingueculum* is a small, yellowish nodule in the conjunctiva in the area of the palpebral fissure on either the nasal or the temporal side of the cornea. It probably occurs as a result of prolonged irritation. It is a slow-growing, noninflammatory, yellow, elevated nodule, characterized pathologically by hyaline degeneration of the subconjunctival tissue. It may be removed by simple excision and closure of the conjunctiva.

*Pterygium* is a fleshy, vascular, triangular growth of conjunctiva and subconjunctival tissue which extends into the cornea, replacing corneal epithelium and Bowman's membrane. Its cause is unknown, but it seems to be related to prolonged irritation. It is most common in people who are exposed to various forms of irritation of the conjunctiva, such as farmers, sailors, laborers and persons working in irritating smokes and dusts. Pterygium usually affects the nasal portion of the cornea in the area of the palpebral fissure but may occur on the temporal side or on both sides simultaneously. Usually both eyes are involved. The lesion grows slowly, the apex gradually extending farther and farther across the cornea. Vision usually is not greatly disturbed until the apex of the growth reaches the pupillary portion of the cornea. Treatment usually consists of transplantation of the growth under the lower bulbar conjunctiva, but this must be done before the apex of the pterygium reaches the pupillary portion of the cornea if good vision is to be saved for the patient. However, the operation should not be performed too soon because recurrences are common. The pterygium should extend at least 2 to 3 mm. over the limbus into the cornea but not to the pupillary margin if best results are to be obtained. Because of the possible complications and because of the frequency of recurrences even under the best circumstances, this is another example of minor surgery that requires skill and care.

*Epithelioma* of the conjunctiva is a malignant growth usually situated at the limbus. It occurs in old people as a small, slowly growing, reddish tumor. Several large subconjunctival vessels supply the tumor and are of suggestive help in the clinical diagnosis These tumors usually arise from a small point at the limbus, develop a short neck, then flatten out like a mushroom. As they increase in size the neck or stalk becomes thicker or larger in diameter, but this is much

or behind the surface of the auricle itself. If the patient attempts to evacuate such cysts, or if they are allowed to persist, they usually become infected. Ideally, they should be removed when the duct has become obstructed, as they then are filled with sebaceous material and they can be easily outlined. They should be removed after procaine and epinephrine have been injected around and below the cyst. An elliptical incision is made just beyond the limit of the cyst and the cyst is removed intact. The skin including the duct of the cyst should also be removed. After bleeding has been controlled, plain catgut should be used to approximate the subcutaneous tissue and obliterate the dead space. The cutaneous edges should be approximated with cotton, silk or dermal sutures If, however, the cyst is ruptured during removal, then all of the sac should be excised and a small dermal drain should be inserted before closure.

Sometimes these cysts become secondarily infected and must be evacuated. After incision and drainage, the lining of the cyst should be cauterized with pure phenol followed by alcohol. The silver nitrate stick may also be used as the cauterizing agent. If allowed to remain open after this procedure, the cyst wall will slough and be evacuated. This, however, requires several days and usually results in cicatrization. The method of choice is excision and primary closure whenever possible. In many instances there are numerous small or multiloculated cysts. These can be destroyed by means of the Bovie high frequency unit or electric needle

*Epitheliomas* frequently occur on the auricle, chiefly on the helix The upper and exposed surfaces are the commonest sites. These growths should be completely excised after local anesthetization with procaine and epinephrine. The subcutaneous tissue down to the perichondrium should be removed. Excision is preferable to radium or roentgen ray because of the danger of perichondritis.

*Hematomas of the Auricle.* Small hematomas should be evacuated with use of a local anesthesic. All clots should be removed, the wound closed primarily and a pressure dressing kept on for the first 24 to 48 hours. If the hematoma is extensive, the clot should be removed with use of a general anesthesic, and after primary closure a splint of dental compound should be applied to the area so that the subcutaneous tissue may become adherent to the perichondrium. If hematomas are not evacuated promptly, secondary infection usually develops as the result of trauma, with the possibility of perichondritis and chondritis and a resulting deformity of the auricle. Examples of infection and deformity are cauliflower ears of prize fighters and professional wrestlers.

*Furuncle of the external canal* is a frequent complication of external otitis from eczema, fungi or small grains of sand and dirt getting into the canal during swimming. The irritation of the canal causes itching with subsequent attempts at relief by scratching with a fingernail, bobby pin, match stick or any object that can be introduced into the canal. The skin of the canal is usually macerated from the water from swimming or from fungi or eczema, and the surface epithelium is easily lacerated. As a result infection gains entrance into the hair follicles or small ceruminous and sebaceous glands.

Little subcutaneous tissue and practically no areolar tissue lie between the epithelium and the perichondrium so that swelling in this location produces pain out of proportion to the amount of involvement. Moreover, because of the scarcity of connective tissue these infections are not readily localized. For this reason, they should not be incised and drained but should be allowed to become thoroughly walled off and in most cases they evacuate themselves. After spontaneous rupture the core or purulent secretion may be expressed. When furuncles are seen early, tampons of Cresatin, Ergophine or some hygroscopic agent, plus heat should be applied. The pain may be controlled by mild sedation, and within 24 to 48 hours the furuncle should evacuate itself or be walled off sufficiently to be evacuated. Recurrence

*Chapter 24*

# Ear, Nose and Throat

*By Mercer G. Lynch*

## Anesthesia

A local anesthetic is preferable for most minor surgical procedures of the ear, nose and throat, principally because the area to be anesthetized in most instances is mucous membrane easily accessible for topical anesthetization. Any one of a number of anesthetic agents may be employed Selection depends upon toxicity, shrinking ability, absorption rate and endurance of the anesthetic, as well as upon the choice of the surgeon and the individual patient. The most popular topical anesthetic agent is cocaine. Pontocaine, Larocaine and procaine are also widely used Some have more advantages than others in specific cases, but basically they are all good.

Certain fundamentals should be borne in mind when using any anesthetic preparation. All of them are more or less toxic. Moreover, some persons are more susceptible to the toxic effects of one drug than they are to another and in different amounts. Therefore, certain precautions should be taken when these topical anesthetic agents are employed As little of the solution as possible should be used to obtain the desired amount of anesthesia, which should be based upon the extent of the surgical procedure and the length of time required. The anesthetic agent employed should be mixed with a constricting agent, such as ephedrine, epinephrine or Neo-Synephrine, since use of these drugs in conjunction with the anesthetic agent retards its absorption and also aids in hemostasis.

If cotton packs or tampons are applied locally, they should be compressed almost dry, and if cotton applicators are used, the excess solution should be shaken off before the applicator is applied. The reason for this is that this excess may remain in the nasopharynx or in some recess of the nose for continued absorption, or it may run into the pharynx, where it is swallowed and eventually absorbed from the stomach.

If the drug is to be instilled directly into the pharynx or larynx by atomizer or cannula, a weak concentration is safer. Time should then be allowed for the area to become anesthetized after which additional solution may be applied, if necessary. In this way anesthesia will be as complete as if a stronger solution were used or a larger amount of the weaker solution were used at one time, and the chances of toxicity are greatly reduced. As a preliminary to the use of more than 1 cc. of these drugs, one of the barbiturates should be given beforehand, the amount depending upon the extent of the procedure and therefore being directly proportionate to the amount of anesthetic agent necessary. In addition to barbiturates in capsule and tablet form and intravenous solutions, cardiac and respiratory stimulants should be available in every office where this type of local anesthetic is employed.

## EAR

***Sebaceous Cysts.*** Many minor conditions may affect the external ear, both the auricle and the canal. Sebaceous cysts may arise within the canal or externally on the auricle. The commonest site is the lobe or lobule of the ear. These cysts may occur on the anterior surface but most commonly they appear on the posterior surface and on the mastoid process

tum result from trauma to the nose, such as a fall or a kick. These may also complicate submucous resection when hemorrhage occurs between the mucosal flaps. Traumatic hematomas or abscesses are usually associated with subperichondrial hemorrhage, which generally occurs bilaterally and produces nasal obstruction. On examination the mucosa of the septum may be seen bulging into the inferior meatus on one or both sides. On palpation this is soft and fluctuant.

Treatment consists of incision and drainage because, if the hematoma persists, it is likely to become infected, with resulting abscess and necrosis of cartilage. This produces a nasal deformity and depression of the cartilaginous portion of the bridge. The mucous membrane of the nose and septum should be sprayed with a 1 per cent solution of cocaine or a 2 per cent solution of Pontocaine. Cotton tampons saturated in a 10 per cent solution of cocaine should then be placed against the mucous membrane and allowed to remain for several minutes. The site of incision, just posterior to the mucocutaneous junction, may be injected with a 1 per cent solution of procaine. The incision is begun above as high as possible and carried down to the floor. Then a horizontal incision is extended posteriorly along the floor, forming an L-shaped flap. Otherwise the vertical incision is apt to close and poor drainage or none at all will result. In many instances it is recommended that the membrane be removed at the junction of the vertical and horizontal incisions by means of punch forceps to insure better drainage. Following this incision the membrane should be separated and the old clot removed by bayonet forceps or by suction. A small rubber dam drain should be inserted. Chemotherapy should be instituted as prophylaxis against development of abscesses. The patient should be seen daily, the incision opened and any old clots removed. After several days the same procedure may have to be carried out on the opposite side and, of course, should be done simultaneously if the abscesses or hematomas are bilateral.

*Nasal Fracture.* Fracture of the nose usually involves the nasal bone and one or both of the nasal processes of the superior maxilla. There may or may not be associated displacement of the septal cartilage. A blow or fall in which the nose is struck at the base of the columella, producing the direction of force upwards and inwards or upwards and laterally, may also fracture or displace the premaxillary bone.

Symptoms include nasal hemorrhage due to tearing of the mucous membrane, pain, swelling and deformity. Within 24 hours after injury swelling increases and ecchymosis involving one or both lower eyelids, and at times the upper lids as well, may be evident.

Examination will usually show some deformity, with the nasal tip displaced to one side and a depression of the nasal process of the superior maxilla. This depression occurs on the side of the blow, and when severe, there may be a slight bulge on the opposite side if the nasal process of this side has also been fractured. The nasal bone or bridge may have a hump or depression and likewise may be displaced to either side. With the index finger along the nasal process on each side, application of alternate pressure of the fingers reveals crepitus and may indicate complete movement of the bone. Palpation produces pain along the fracture. However, these findings are usually obtained only during the first 48 hours, after which union begins and it is difficult to determine accurately the extent of the swelling and tenderness. Examination of the nasal cavity by means of the speculum will reveal tearing of the mucous membrane of the septum or of the lateral nasal wall in the region of the middle turbinate.

These fractures should be treated early before swelling or ecchymosis has had time to progress. The nose should be sprayed with a 1 per cent solution of Pontocaine, and then a 10 per cent solution of cocaine should be applied to the superior meatus in the region of the ethmoidal nerves and along the septum high in the region of the nasociliary nerve. Many instruments have been de-

is common; in such cases systemic antibiotic therapy is a wise precaution.

*Hematomas of the Tympanic Membrane.* Hematomas, or collections of serous fluid within the tympanic membrane, are often associated with influenza or systemic virus infections involving the nasal passages and nasopharynx. They may be incised without use of an anesthetic after the ear has been thoroughly cleansed of cerumen followed by application of alcohol on a cotton swab. This should be done under aseptic conditions and care should be taken to avoid complete incision of the drum membranes. Once evacuated, the condition subsides.

*Otitis Media.* In infections of the middle ear cavity complicating infections of the upper respiratory tract or collections of fluid following catarrhal or serous otitis, it is necessary to incise the drum membrane. The drum has a dirty gray or hemorrhagic appearance in the acute cases, and in serous otitis a fluid level may be seen. All or most of the normal landmarks may be destroyed, and there is an outward bulging of the membrane from the pressure of fluid or air within. After the canal has been thoroughly cleansed of cerumen and debris, it may be sterilized and the drum incised under local or general anesthesia A local anesthetic is preferable, not only because of the convenience but also because this condition is often associated with an infection of the upper respiratory tract. A solution of cocaine, phenol, menthol and glycerin is used for local anesthesia. The patient should be made to lie on the side opposite the involved ear. The canal should be almost completely filled with the solution, this requires about 5 or 6 drops. The solution should be allowed to remain in place for from 20 to 30 minutes, after which it should be removed and the skin of the canal sterilized with a cotton applicator saturated in alcohol.

The hand of the operator rests upon the patient's head to prevent plunging of the knife inadvertently if the patient should move. An L-shaped or curved incision should be made in the posteroinferior quadrant of the drum. Care should be taken not to touch the inner wall of the inner ear, as an exposed facial nerve may be encountered in this area, or if the knife is plunged in, it might enter the labyrinth. Although rare, these accidents have occurred. In infants and young children, dehiscence of the jugular bulb sometimes occurs; upon occasion this has been incised with resultant profuse bleeding. If this should occur, packing the external canal will control the hemorrhage, but because the incision has been made in an infected area, general systemic measures should be employed as prophylaxis against septicemia.

After incision of the drum membrane, the patient should be made to lie on the involved side to promote drainage. After incision in acute cases, irrigations or drops should be avoided. The canal should simply be wiped with sterile swabs, and sterile cotton tampons should be inserted into the canal.

*Granulations or Polyps of the Middle Ear.* In the chronically diseased ear with long-standing perforation and discharge, granulations or polyps are frequently seen protruding from the middle ear through the perforation. These may be removed by the same type and method of local anesthetization as used for incising the drum. However, in these cases the polyp should be removed by means of the aural snare, middle ear cup or biting forceps. It should never be pulled or removed bluntly because the infection is of long standing and there may be erosion of the facial canal, attachment to the stapes or erosion of the tegmen and exposure of the dura; in attempting to pull the polyp out instead of biting it clean or snaring it, one is apt to injure the facial nerve or produce labyrinthritis or meningitis.

## NOSE

A topical anesthetic is more widely used in the nose than in any other portion of the body. Most nasal conditions requiring minor surgical procedures can be treated with the use of a local anesthetic agent.

*Hematomas and abscesses of the sep-*

bottle by means of compressed air or by hand, but at all times only enough pressure should be employed to maintain the flow. The advantages of this method are that it produces little or no trauma or reaction and it is the least painful of all methods, so that it can be employed daily for several days in the first stages of retained pus. Also, as a diagnostic wash this method has no bad after-effects.

The method just outlined cannot be used in patients with a severely deviated septum anteriorly, polypoid degeneration of the middle turbinate or hypertrophied middle turbinates plastered against the lateral nasal wall. In such cases one must resort to puncture beneath the inferior turbinate, which is then elevated slightly medially so that one may reach high up against the lateral nasal wall in the area of the thinnest portion of the bony wall. The trocar should be placed in this region and pressure exerted upward and outward towards the outer canthus of the eye. Any one of several trocars or punches or even spinal needles may be used. Again gentle pressure should be applied in washing. Following this procedure a cotton applicator saturated with epinephrine or ephedrine should be inserted in the region of the puncture and left in place long enough to control bleeding. This procedure should never be done more frequently than once every 48 to 72 hours. Moreover, if it is necessary to wash a sinus for some time, a more permanent opening should be made by enlarging this puncture with a rasp and punch forceps.

*Nasal Polyps.* Polyps occurring in the region of the ethmoid and middle turbinate, as well as protruding from the ostia of the antrum into the middle meatus, are generally associated with allergic conditions. Because of mechanical obstruction to the airway and blockage of drainage of the sinuses, producing secondary infection, they have to be removed. If the allergic condition is not treated or relieved, the polyps are apt to recur. Most of them are polyps with secondary edema or hydrops of the tissue in chronic cases, but occasionally fibrous polyps are encountered.

A topical anesthetic is employed in these cases. The mucous membrane of the nose should be sprayed with a 1 per cent solution of Pontocaine. However, in large polyps which require shrinkage to facilitate removal, a 5 to 10 per cent solution of cocaine may be employed. The patient should be warned against swallowing any excess solution. For this reason, only a small amount should be used. A cotton applicator with a 10 per cent solution of cocaine should be applied to the base of the polyp; after a few minutes the area becomes cocainized. A nasal snare should then be introduced, the polyp encircled as high up toward the base as possible, and the snare closed in place. Remnants should be removed with the punch or biting forceps. Polyps should never be pulled out with the snare but should be cut clean. Likewise remnants should not be pulled out but should be removed by sharp biting. The reason for this is that in long-standing polypoid degeneration of the ethmoids, dehiscence of bone might be present and if the polyp is pulled, tearing the membrane, meningitis, orbital hemorrhage or cellulitis might result. After removal, ephedrine or epinephrine packs applied to the area will control bleeding.

*Rhinoliths*, or stones, are encountered in patients of all ages. They are found usually on the floor of the nose but may become embedded in the tissues. They generally occur in the inferior meatus but occasionally are found in the middle. If large, they may perforate the septum and lie in both nostrils or extend from the anterior or posterior nares. There is usually a nucleus consisting of a small foreign body, dried blood or mucus, or a piece of necrosed bone. Chemically, these stones consist chiefly of calcium phosphate and magnesium carbonate. They may also contain large masses of bacteria. Rarely are they multiple. They usually form rounded or oval masses with sharp angles and irregular outlines, and vary in color from grayish brown to dark green. The color is probably due to blood pigment. Most are similar in consistency but occasionally they may be extremely hard. The symptoms are

vised for reduction of nasal fractures but any long, thin, strong metal, such as the handle of a Bard-Parker knife, is satisfactory. This is wrapped in cotton and covered with petrolatum and, after removal of the cocaine packs, is gently inserted into the nose as far posteriorly as the level of the fracture and as high as the vault. Then, by exerting pressure upwards to elevate the nasal process of the superior maxilla, the operator may carry the pressure laterally and at the same time displace the bone into position. However, if external pressure is required, this may be accomplished by the thumb of the opposite hand. Usually a definite "click" or "snap" is heard as the bone falls into place.

It is important to inspect the septum carefully to be certain it is in the midline and not displaced out of its bed in the palatine bone. The reduced nasal bone and nasal processes will *not remain* in place if the septum is displaced unless held by a splint. Moreover, a deviation of the septum is produced which may later cause nasal obstruction requiring submucous resection Varied types of nasal splints are available, but in the early stages of fracture with reduction of the septal deformity, these are not necessary. It is sometimes wise to use a nasal splint made of lead sheeting. This is cut to the size and shape of the nose, covered with adhesive tape and molded to the nose. It is held in place by adhesive strips. The principal purpose of this is to protect the nose from light superficial trauma and to keep the patient's hands away from the area. Within 72 hours this makeshift splint may be removed.

The nose is kept clean and open by use of mild nasal drops, suction and shrinkage in the office Immediately after reduction and for the first 72 hours, cold compresses should be used, followed by heat to increase absorption. Superficial lacerations may be cleansed and sutured in the office following sterile technique Fractures seen after 72 hours, and compound fractures, should be reduced in the hospital and corrected with use of general or local infiltration anesthesia and sterile technique.

***Infections of the antrum*** require drainage if the sinus contains an accumulation of pus. The symptoms are those produced by pus under pressure, that is, pain over the superior maxilla, tenderness on pressure, occasionally in acute cases swelling over the cheek, pain of the upper teeth on the involved side and usually severe supra-orbital headache. Nasal examination shows an accumulation of pus in the inferior meatus; upon aspiration of the pus and shrinkage of the membranes, pus may be seen in the middle meatus and often a stream or streak from under the middle turbinate.

Drainage may be accomplished either by irrigation through the natural ostium or by puncture beneath the inferior turbinate. However, in acute cases and especially in patients with fever and *swelling of the cheek, no attempt* at puncture should be made because of the danger of septicemia. The antrum should be washed through the natural ostium, or shrinkage sprays and antibiotics should be employed until the acute condition subsides and the infection becomes localized. If the condition is deemed ready for washing, the nose should be sprayed with a 1 per cent solution of Pontocaine, the mucous membranes and turbinates shrunk with some shrinking solution, such as Neo-Synephrine or ephedrine, and an applicator with cotton saturated with a 10 per cent solution of cocaine applied to the middle meatus under the middle turbinate or under the inferior turbinate between it and the lateral nasal wall. These applicators should be left in place for several minutes until the region is anesthetized If one is washing through the natural opening, any one of several cannulas may be used. The cannula should be inserted in the inferior meatus and gently palpated for the natural ostium, which in many cases is surprisingly large Other cannulas for this procedure are pointed so that one may puncture the membranous portion of the antrum. Gentle pressure should be applied to the wash

a post-nasal pack must be used. This is made by rolling a gauze square tightly and holding it with three strings placed in the middle of the roll. The gauze is then soaked in tincture of benzoin or a 20 per cent solution of mercurochrome to deodorize the pack. A size 10 catheter, or any size available up to size 18, should be inserted into the nostril and the tip withdrawn through the mouth. One of the strings should be attached to this catheter and then withdrawn through the nose so that the string is brought through the mouth and posterior nares out through the nostril. This procedure is then repeated through the opposite nostril and by gentle drawing of these strings and the use of a curved tonsil hemostat the pack should be inserted into the nasopharynx. It should be pressed gently in place with the finger. The two strings protruding from the nostrils should be tied after a gauze pad had been placed over the frenulum to protect it from being cut by the string if undue pressure should be applied. Therefore, these strings should be tied just tightly enough to hold the pack. The nose may then be packed anteriorly in the same way as described before, layers of petrolatum gauze being used. The post-nasal pack should not be left in place for more than 48 hours because of the danger of infection of the eustachian tubes and otitis media. If tight postnasal packs are left in place any longer than this, edema of the eyelids and bridge of the nose due to lymphatic stasis, and somnolence and disoriention may occur.

On occasion the hemorrhage recurs after removal of the packs and both the anterior and postnasal packs must be reinserted. Administration of vitamin K will at times help. The best supportive treatment, and ofttimes the means of preventing recurrences, is administration on successive days of three small blood transfusions of from 250 to 500 cc, depending on the blood loss and the condition of the patient. Whole blood is preferable to any other type

It may prove impossible to control these seemingly minor or repeatedly profuse hemorrhages by minor surgical procedures. In such cases the antrum should be opened and packed, and the external ethmoidal vessels, the sphenopalatine artery and at times the external carotid artery may have to be ligated.

*Removal of the middle turbinate* is often indicated to promote better drainage from the ethmoids, and especially the frontal sinus. In patients with a normally narrow airway and a large hyperplastic middle turbinate, or in those whose middle turbinate has been plastered against the lateral nasal wall, inhibiting drainage and ventilation of the sinuses, it may become necessary to remove the anterior third or two-thirds to promote proper drainage and ventilation and thus avoid more extensive surgical procedures. This may be done under local anesthesia. After thorough cocainization of the region of the superior meatus and olfactory area as well as the lateral wall of the nose beneath and above the middle turbinate, the middle turbinate should be fractured medially. The turbinectomy scissors should then be placed as high up as possible to the attachment of the middle turbinate and the turbinate cut along its attachment as far back as necessary to accomplish the purpose. This usually means the anterior third and often the front part or entire middle third of the turbinate also. The snare should then be introduced and the turbinate engaged as far back as possible before the snare is closed. Usually hemorrhage may be controlled with an ephedrine or epinephrine pack left in place for several minutes, but sometimes bleeding is rather profuse and requires an anterior nasal pack of petrolatum gauze for 12 or 24 hours. When this is removed, the patient should be instructed to use mineral oil drops in the nose for several days to keep the blood clot soft so that when separation occurs bleeding will not recur.

## THROAT

*Peritonsillar Abscess, or Quinsy.* This deep-seated infection of the tonsillar tissues gives rise to a distinct abscess located in the tissue surrounding the tonsil. It occurs much less frequently now than

the same as those of a foreign body. Characteristically, there is a unilateral purulent blood-stained discharge. If large enough, the stone may cause nasal obstruction, which in turn produces headache and facial pain from pressure, and if secondarily infected, febrile symptoms.

Treatment consists in removal of the stone, but before removal is attempted it may be necessary to reduce the size of the rhinolith either by cutting with scissors or crushing. Rhinoliths are usually difficult to remove because they are embedded in the tissues. Removal of extremely large rhinoliths is a major procedure requiring a general anesthetic.

*Nasal hemorrhage* is always disturbing and frequently serious. It usually is due to rupture of a small vessel on the anterior third of the septum in the anastomosis of the coronal branch of the facial, septal and palatine branches of the sphenopalatine so that a plexus is formed in this area. The bleeding may also arise from the inferior turbinate, the membranous portion of the medial wall of the antrum or the posterior third of the middle turbinate. If it is the result of operative trauma, it may arise anywhere. The commonest causes are hypertension and postoperative trauma; however, there are many systemic diseases and blood dyscrasias that may produce nasal hemorrhage. Vicarious menstruation is not an uncommon cause in adolescent girls. Sometimes the hemorrhage is spontaneous without any apparent cause, and may be quite severe. In these cases one should always be suspicious of neoplasms, especially malignant ones

Although control of nasal hemorrhage may be simple, at times it taxes the ingenuity of the physician. Simple hemorrhages from the septum may be controlled by application of cold compresses to the bridge of the nose, pressure on the upper lip beneath the frenum of the nose and elevation of the head. A 1:10,000 solution of epinephrine or a 3 per cent solution of ephedrine on cotton tampons may be applied to the area. Sometimes if the bleeding persists, a petrolatum gauze pack applied for 12 hours will arrest it.

It is not wise to try to cauterize the bleeding point during active hemorrhage, as a solution spreads over the surrounding membrane and produces further irritation, and the Bovie unit or electrocautery cannot be satisfactorily used in a wet field. However, after bleeding has been controlled, the bleeding point should be cauterized. This is accomplished either with caustics or sclerosing solutions, such as the silver nitrate stick, chromic acid, trichloracetic acid or 50 per cent solution of silver nitrate. The Bovie unit, the high frequency current or the electrocautery may also be used, but care should be taken to protect the surrounding surfaces and to cauterize only the bleeding area. Cauterization should not be too deep because of the danger of perforating or injuring the cartilage, subsequent slough and severe secondary hemorrhage.

If the hemorrhage is severe or the bleeding area not visible, the nose should be packed. Simply pushing petrolatum gauze packing into the nose is not sufficient. Packing should be done systematically by placing the gauze strip on the floor of the nose as far posteriorly as is necessary. The gauze should then be folded upon itself in layers so that an even pack will result. Such a pack will be easy to remove and should not cause more bleeding during removal.

General oozing or profuse bleeding from the mucous membrane surfaces due to blood dyscrasias or general debilitating diseases and excorciations may be controlled by cotton tampons moistened with a 50 per cent solution of glucose and placed in the nose over the bleeding area. This should not be left in place longer than 1 or 2 hours because of the sclerosing effect and the danger of secondary slough Bacon rind can be applied with excellent results in some of these cases but should be removed in 12 to 24 hours. Gelfoam packs will often control this bleeding but they tend to form a dense fibrous clot which is sometimes difficult to remove.

Bleeding from the posterior portion of the nose is sometimes difficult to control by means of an anterior pack so that

It is my belief that lateral and postpharyngeal abscesses are major surgical problems.

Although a great number of peritonsillar abscesses will find a point of least resistance, rupture, and eventually empty themselves, in the majority of cases they will have to be opened and drained. If the abscess is large, drainage is not difficult. However, in the smaller abscesses with a great deal of inflammatory reaction the most likely place to reach the pus must be determined. Sometimes after a deep incision no pus escapes. Yet in the course of a few hours the symptoms are relieved. This is due to diminution in tension as well as the fact that the pus works its way towards this opening.

The operative procedure is simple if certain rules are observed. In the majority of cases the peritonsillar abscesses are supratonsillar, occurring in the superior tonsillar fossa. The bulging is therefore above and outside the tonsil. There are several methods of determining the site of incision for deep-seated abscesses in which no area of thinning or fluctuation can be demonstrated. One method is to draw an imaginary line along the anterior pillar at its most bulging point and another along the free border of the soft palate; the incision should be made at the junction of these two lines. Another method is to start the incision at a point midway between the base of the uvula and the upper wisdom tooth on the affected side. Most abscesses involve the supratonsillar fossa and cause severe bulging of the anterior pillar. Usually by palpation the area of fluctuation, which is the most prominent point of bulging, can be felt and should then be incised.

Although usually completed in a few seconds, the procedure is extremely painful. Therefore, an attempt should be made to anesthetize the area before the abscess is incised. The area of the anterior pillar should be painted with a 10 per cent solution of cocaine on a cotton applicator. The site of incision should then be injected with a 1 per cent solution of procaine. The needle should not be plunged into the pillar but merely inserted beneath the mucous membrane and a blister produced. If the injection is made deeply, there is a possibility of spreading the infection beyond the abscess.

Incision of these abscesses is not without danger. For example, the ascending pharyngeal or external carotid artery might be injured. I have seen one case of injury of the external carotid and one of injury of the internal carotid artery and heard of two others besides a case with injury of the internal jugular vein. Two of these patients died and the other two were saved only after use of heroic measures.

Any sharp instrument, either scissors or knife, may be used provided it has a guard to prevent too deep insertion at the initial plunge. For practical purposes, a Bard-Parker handle with a pointed blade around which has been wrapped adhesive tape ½ inch from the point, forming a guard, is as good as any. The point should be inserted at the desired location and carried down along the anterior pillar. In the superficial abscess there is usually a gush of pus; after this a tonsil hemostat should be inserted into the incision and the lips of the incision spread widely apart. The patient should then be given an antiseptic mouth wash, usually hot, to rinse the mouth. Better still is the use of hot throat irrigations with saline solution; the ordinary enema can or a suitable container holding about a quart of water may be used. The patient leans over a basin and, breathing through the mouth, irrigates the area of the tonsil. This is not only soothing but helps to promote drainage. Sedatives and mild opiates are given for the relief of pain, which usually subsides spontaneously shortly after the abscess is drained and the pressure relieved.

***Submaxillary stones*** are fairly common. Unless they are located near the opening of the duct or are small enough to be removed by simple dilation of the duct, they should not be removed in the office because, although so many of them seem to be easily palpable, they actually have become adherent to the walls of the duct as a result of previous trauma

formerly, because the use of antibiotics has aborted formation of abscesses in many cases. The condition may follow an attack of acute tonsillitis or may arise spontaneously at any time as a result of a chronic infection of the tonsil It is due to deep crypts containing infection which produce no symptoms and it suddenly makes itself manifest, forming in the least resistant part an abscess, which may point in any direction. It occurs more often in adults than in children. In children, however, it is more prone to be associated with cervical adenopathy and external swelling.

The acute abscess must be differentiated from the latent abscess In the acute cases, during or after an attack of acute tonsillitis, there is an agonizing pain on one side of the throat, usually extending to the ear, and frequently associated with some degree of fever, which may vary in different cases from 99° to as high as 106° F. Usually, the temperature is higher in children than in adults, but this depends upon the virulence of the organism and the resistance of the parts to the spread of the infection

Local symptoms are frequently pathognomonic of the condition. Besides the excruciating pain, which often extends to the ear, the patient has great difficulty in swallowing. The muscles of the jaws are so rigid that the mouth can scarcely be opened, and attempts to open it are associated with severe paroxysms of pain. The glands of the neck, especially in children, are enlarged and tender. There is associated general malaise, depending upon the systemic reaction If the tongue is firmly depressed, a swelling or bulging of the anterior pillar of the tonsil and adjacent soft palate on the affected side will be noted. In a few cases this is so great as to obstruct nasal respiration and progress forward, dissecting the tissues of the hard palate. The amount of the systemic reaction is not dependent upon the size of the abscess. An extensive inflammatory reaction may be present about a small abscess cavity. In these cases the glands of the neck are usually involved.

The pathologic alterations are similar to those of abscesses elsewhere. There is extensive infiltration of all the tissues of the throat on the affected side and severe edema of the mucosa. The inflammatory tissue surrounding the abscess cavity may be thick, measuring 1 or even 2 cm., whereas in other cases the abscess is nearer the surface and is but thinly coated with inflamed mucous membrane.

The systemic complications will depend upon the severity of the underlying causative factors, such as acute tonsillitis. At times the abscess spreads posteriorly to produce a lateral pharyngeal abscess. However, the most serious complication is spread or rupture into the pharyngomaxillary fossa, producing an abscess or even involving the carotid sheath with thrombosis of the internal jugular vein. Such conditions are major surgical problems. These possibilities should be kept in mind, though, both at the first examination and at subsequent examinations. Local complications depend upon the size of the abscess and the resulting destruction and scarring. The pain in the ear is for the most part referred, but otitis media can occur by extension into the eustachian tube.

The prognosis is usually good despite the possible complications, because the usual course of the abscess is to point into the mouth and rupture before any serious complications can develop. It is those abscesses that take a long time to develop in which the difficulty lies. One is prone to incise the swollen, edematous anterior pillar before fluctuation has occurred and the abscess has become walled off; in such cases there is a possibility of spread of the infection.

In children there is likely to be a small localized abscess producing little or no fever and no symptoms until it ruptures or spreads deep in the neck. Careful examination and history are important One should always go further and look for lateral or postpharyngeal abscesses when the tonsils appear relatively normal in patients with pain in the ear and throat, difficulty in swallowing and fever.

home a razor blade is usually available.

The patient is placed on the couch or bed with the neck extended over the side, or a coat is placed under the shoulders so that the neck is extended. The site of incision is the next question. In the classic tracheotomy a vertical midline incision is made from the lower border of the cricoid cartilage to the upper border of the suprasternal notch in the anterior jugular vein. Strap muscles and the thyroid gland are encountered in this approach, and when done at leisure, bleeding is easily controlled. However, when time is limited this approach cannot be adequately used, especially if no suction apparatus is available. Often the only available instrument is a pocket knife or a razor blade.

A horizontal incision is made instead of the classic vertical one (Fig. 333). This is made in the cricothyroid membrane as closely as possible to the cricoid cartilage, because in this way the inferior laryngeal artery is less likely to be encountered and its branch is thus less likely to pierce the cricothyroid membrane. With the neck extended the thyroid and cricoid cartilages can usually be easily felt. The only vessel encountered is the anterior jugular vein, which is often small; even if it is enlarged, bleeding is relatively easily controlled by pressure of the fingers above and below the incision. As soon as the cricothyroid membrane is incised and respiration is established, or the patient is allowed to take several deep breaths, the incision is held open partially by the patient keeping the head extended and partially by means of improvised retractors, made of hairpins, the ends of which have been twisted together. The curved end is bent at an acute angle and this end inserted into the lateral edges of the wound. These retractors are held in place by tying a string to the twisted ends of the hairpin and then tying this behind the patient's neck.

With these rather permanent retractors in place and an adequate airway established, the patient may be transported to the hospital where, with use of a local anesthetic, with suction and oxygen available, one may proceed under sterile conditions and without undue haste to perform the regular classic tracheotomy and, this being completed, to close the incision in the cricothyroid membrane. If this is closed early and the cricoid cartilage has not been injured, there will be no chance for development of stricture.

### ESOPHAGUS

Because of the anatomic variations of the esophagus, which are, with few exceptions, greater than in any other organ of the body, instrumentation of this organ can be exceedingly dangerous. There are, however, some more or less normal variations with age, height and body weight. Not only does the size of the lumen vary in different individuals

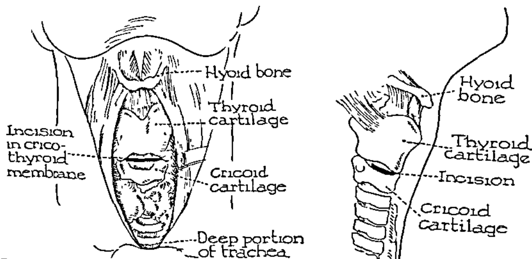



*Figure 333.* Diagram showing landmarks and horizontal incision for emergency tracheotomy.

or irritation. More commonly, in an attempt to remove the stone, it slips back through the dilated duct into the gland.

In the case of stones located near the opening of the duct a 1 per cent solution of procaine is injected about the duct, after which a suture should be placed beyond the stone, between the stone and the gland This suture must be deep enough to include the duct and serves merely as a stay suture to prevent the stone from slipping posteriorly in the already dilated portion of the duct. One may then begin at the puncta and slit the duct or cut directly down upon the stone. As soon as the stone is encountered, it should be grasped and delivered. No attempt should be made to suture the incised duct. Bleeding is minimal. The patient should be instructed to use an antiseptic mouthwash for several days. Stones located distally from the puncta in the duct near the gland should be removed in the hospital

***Parotitis.*** Parotitis, the infectious childhood disease known as mumps, is by far the commonest cause of swelling of the parotid gland However, localized abscesses and obstruction to the main duct or to the branches due to small stones, epithelial debris or concretions are occasionally encountered Many of those occurring in the buccinator and masseter portions, that is, the superficial portion of the gland, may be taken care of in the office. Dilatation of the puncta, with the ophthalmologic puncta dilator, followed by eustachean tube whalebone dilators, may dilate the duct enough for escape of the stone or for adequate drainage. Once dilated, the duct and proximal portion of the gland may be irrigated with sterile saline solution. At times antibiotics may also be instilled. Heat should be applied and the patient advised to chew gum once the duct is dilated and drainage established. Under no circumstances should the duct be incised, as in the case of the submaxillary gland, because stricture is likely to follow.

In cases following external injury, such as stab wounds or lacerations, if the capsule is not sutured, a fistula may develop Small fistulas may be completely dried up by roentgen ray therapy, drying up that portion of the gland, but this is unsatisfactory for fistulas near the main duct, which require surgical repair of the capsule.

### Biopsy

Biopsies of the nose, nasopharynx, pharynx, hypopharynx and base of the tongue and epiglottis as well as the floor of the mouth and tonsillar region may all be carried out in the office under local or topical anesthesia. As a rule bleeding is easily controlled. It should be remembered that a negative result of biopsy of a suspicious lesion is not definite proof and repeated biopsies of any suspicious lesion are indicated, for only in this way can the early diagnosis of these lesions be positively established and the necessary steps taken for their eradication.

### Tracheotomy

Tracheotomy is usually a hospital procedure, performed under sterile conditions and with sterile technique. Not only is it performed to provide an adequate airway but also to facilitate pulmonary drainage and aspiration of secretions in brain surgery. It may be indicated in patients with poliomyelitis, meningitis, or other serious conditions in which the patient is unconscious or semiconscious for a prolonged period of time. It may also be employed before extensive oral or maxillary operations for malignant lesions to facilitate postoperative care.

At times tracheotomy is a life-saving procedure and in these circumstances becomes an immediate emergency. This may occur in the office as a result of anaphylaxis or other circumstances producing sudden edema of the glottis or larynx. It may occur in the home and occasionally in the street after automobile or other accidents. Under these circumstances sterile technique may have to be abandoned because of the immediate necessity of obtaining an adequate airway. If a scalpel is not readily available, a pocket knife will suffice. In the

*Part VIII*

# The Nervous System

and at different times, depending upon circumstances, but the length varies with height, age and weight. Besides these normal variations four constrictions are normally encountered in passing the length of the esophagus. These may be divided into two main and two minor constrictions. The first of the main constrictions, and most important as well as the tightest, is that at the cricoid cartilage; the other is the diaphragm. The lesser constrictions are in the aortic area at the level of the fourth thoracic vertebra, and the left bronchus at the level of the fifth thoracic vertebra. These normal variations and the anatomic constrictions emphasize the dangers of blind instrumentation or manipulation as office procedures.

The two commonest symptoms referable to the esophagus are difficulty in swallowing and regurgitation of food, immediately after ingestion or within a relatively short time Diseases of the esophagus, such as cicatricial stenosis, spastic stenosis, compression stenosis, benign and malignant tumors, as well as diverticula, ulceration and inflammation, and foreign bodies, may be diagnosed by fluoroscopy and the ingestion of barium followed by flat roentgenograms. The diagnosis is confirmed, however, by esophagoscopy, which is always a hospital procedure performed under local or general anesthesia, depending upon the condition of the patient and the choice of the operator. Every patient should have a roentgenographic examination and direct esophagoscopy before any office procedure on the esophagus is attempted.

Certain selected conditions, such as small webs, solitary strictures, cardiospasms which have not progressed to severe dilatation and distortion of the esophagus, or spastic neurosis, may be treated in the office after a careful roentgenographic and, if indicated, direct esophagoscopic examination. In such cases if the diagnosis has already been made and previous examination has demonstrated no severe stricture or distortion, dilatation may be carried out in the office. For this the mercury-filled bougie and less often the silk-wrapped bougie are used.

The pharynx and hypopharynx are sprayed lightly with a 1 per cent solution of Pontocaine. The finger is then inserted in the midline along the tongue until the epiglottis is felt. The bougie is passed either to the right or left of the finger, entering the pyriform fossa. No pressure is exerted upon the bougie. The patient is instructed to swallow and the weight of the bougie carries it into the esophagus and past the cricoid. Once past this level the bougie usually descends easily until the stricture is encountered Sometimes, however, owing to spasm or the act of regurgitation, the bougie is arrested. It should not be forced out; rather, its position should be maintained and usually after a short interval the spasm will pass, or the patient should be told to swallow and the act of swallowing will carry the bougie further down. The bougie should never be forced down, and use of a larger size should never be attempted until the previous bougie passes easily. After repeated bouginage in the office, the patient may be taught to insert and pass the bougie himself. It cannot be too strongly emphasized that it is extremely dangerous to pass a foreign body down the esophagus into the stomach by bouginage or to attempt any bouginage procedure without first obtaining roentgenograms, usually with a contrast medium, and if any doubt exists, esophagoscopy in the hospital.

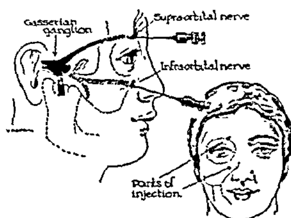



*Figure 334.* Needles inserted into supra-orbital notch and infra-orbital foramen for injection of alcohol into the respective nerves.

case may be (Fig. 334). The patient will complain of pain in the distribution of the nerve. The injection of 0.5 cc. of a 1 per cent solution of procaine will promptly result in partial anesthesia of half the forehead. This is followed by injection of 0.5 cc. of a 95 per cent solution of alcohol. The point of the needle can be moved gradually during the injection so that as many nerve fibers as possible will be damaged. The anesthesia and the relief of pain will persist for many weeks or months, depending upon the effectiveness of the alcohol in reaching all the axons. When the pain returns, the nerve should be avulsed through an incision in the eyebrow. Although this is a hospital procedure, it is preferable to repeated alcoholic injections because the effect of reinjections is short-lived.

*Alcoholic Injection of the Infra-orbital Nerve.* If the pain of trigeminal neuralgia is more or less limited to the cheek, upper lip and side of the nose, a long period of relief may be obtained by injection of alcohol into the infra-orbital foramen. After the foramen has been palpated and the skin marked with the fingernail, the skin is sterilized. Because this foramen points medially and downward, the long hypodermic needle should be inserted into the skin 1 cm. below the foramen and pointed upward (Fig. 334). A little probing is usually required to find the foramen. The needle should be inserted no deeper than 1 cm. into the foramen. Aspiration should precede injection to make sure that the point of the needle is not in the antrum. The injection of a few drops of procaine produces anesthesia of the cheek. This is followed by injection of 1 cc. of a 95 per cent solution of alcohol. The needle should be slowly withdrawn during the injection to increase the chemical damage to the nerve. Many months later, when the anesthesia disappears and the pain returns, the patient should be persuaded to enter the hospital for avulsion of the nerve because secondary injections are relatively ineffective.

*Alcoholic Injection of Maxillary Division.* If the pain of tic douloureux is in the realm of the maxillary division of the nerve, but not confined to the infra-orbital branch, the division can be injected with alcohol at the point where it enters the skull through the foramen rotundum. Until the operator is thoroughly familiar with the procedure, it is well to have an assistant hold a skull near the patient's head to assist him in maintaining three-dimensional orientation. After a superficial injection of procaine hydrochloride, a 22 gauge spinal puncture needle is inserted into the skin of the cheek just below the zygoma (Fig. 335). The point of the needle is directed medially and cephalad; it should strike the base of the skull near the foramen rotundum at a depth of about 5 cm. If the point of the needle pierces the nerve, the patient cries out with pain, which is felt in the upper lip. A few drops of procaine will produce anesthesia in the distribution of the entire division. This should be followed by the slow injection of 1 cc. of a 95 per cent solution of alcohol. Alcohol must not be injected if anesthesia is not pro-

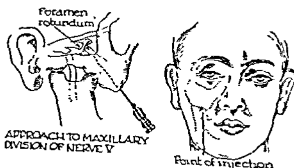



*Figure 335.* Needle inserted toward foramen rotundum for injection of alcohol into maxillary division of trigeminal nerve.

*Chapter 25*

# Diseases of the Nervous System

*By Dean H. Echols and John Davies Jackson*

## TRIGEMINAL NEURALGIA (TIC DOULOUREUX)[1-12]

For many decades, permanent cure of trigeminal neuralgia has been obtained by surgical section of the root of the nerve or alcoholic injection of the gasserian ganglion. The chief objection to these procedures is the resulting anesthesia of the face and mouth and the accompanying unpleasant paresthesias. Important progress in control of the disease was made in 1952 by Taarnhøj,[11] who advocated decompression of the root of the nerve. Somewhat later, it was learned that manipulation of the sensory root and ganglion was more effective than simple decompression. The modified method is sometimes called "the decompression-compression operation on the trigeminal ganglion and root." Its chief disadvantage is the possibility of recurrence of the pain months or years later. The advantage is that the pain is relieved and only patchy sensory loss on the face and negligible paresthesias result. If a major procedure is indicated for tic douloureux and the patient's life expectancy is at least ten years, the decompression-compression operation should be advised. In patients with a shorter life expectancy or those considered poor surgical risks, the nerve root should be sectioned to avoid the possibility of another operation later.

*Injection of the Gasserian Ganglion.* Although in the past injection of the gasserian ganglion was often performed in the office or outpatient clinic, all but the simplest surgical procedures are now done in a hospital. With the patient sedated on the x-ray table, a spinal needle is inserted under the zygoma and its point is passed through the foramen ovale so that it comes to lie within the ganglion. Roentgenograms aid in locating the foramen and in determining the ultimate position of the point of the needle. If cerebrospinal fluid can be aspirated, the needle is withdrawn 1 mm. at a time until the point is out of the subarachnoid space and among the ganglion cells. Injection of a few drops of procaine results in immediate anesthesia of the face. The cells are then destroyed by slow drop-by-drop injection of alcohol or boiling water. Obviously, reference should be made to the writings of those who have perfected this meticulous technique.

*Office Procedures for Trigeminal Neuralgia.* Until a safe, reliable medical remedy for tic douloureux is developed, most patients will continue to receive palliation by means of such office procedures as alcoholic injection of the supra-orbital nerve, the infra-orbital nerve, the maxillary division, the mandibular division and, occasionally, the mental or alveolar branches. In addition to these procedures, the surgeon can section the supra-orbital nerve, and the oral surgeon can section the other branches, including the infra-orbital, mental, lingual and inferior alveolar.

*Alcoholic Injection of the Supra-orbital Nerve.* If the pain of trigeminal neuralgia is confined largely to the eyebrow and forehead, the supra-orbital nerve can be injected with alcohol. The supra-orbital notch is palpated with the finger and its location marked with the fingernail. After preparation of the skin, a long hypodermic needle is inserted into the supra-orbital foramen or groove, as the

There are two reasons for anesthetizing the tonsillar region in a patient suffering from glossopharyngeal neuralgia. One is to establish a diagnosis. The other is to provide relief until the patient can arrange to enter the hospital for intracranial interruption of the nerve, a safe, simple and permanent cure. Occasionally, it is difficult to differentiate between glossopharyngeal neuralgia and neuralgia of the mandibular division of the trigeminal nerve. The tonsillar and eustachian regions so nearly overlap the lower jaw that the patient cannot always tell the exact location of the pain. If Pontocainization results in instantaneous relief and permits the patient to swallow without pain, the possibility of mistaking glossopharyngeal neuralgia for trigeminal neuralgia is eliminated.

After the first application in the office the patient is provided with an atomizer containing a 2 per cent solution of Pontocaine (tetracaine). He readily learns to spray the tonsillar region so that he can eat without pain. Caution must be observed in the use of Pontocaine because of its great toxicity. Obviously, this procedure is not a method of treatment. It merely provides respite for a week or two pending operation or a spontaneous remission.

### FACIAL TWITCHING (TIC) AND FACIAL SPASM[13, 14]

The common facial tic is characterized by twitching of some or all the muscles of expression on one side of the face. It is a permanent handicap which develops insidiously. If the muscles about the eye are affected, the eye is momentarily closed and the patient gives the impression of having deliberately winked. Often the muscles of the lower part of the face are involved and cause retraction of the angle of the mouth. In facial spasm the muscles remain in a state of contraction for many seconds or even longer. The eye is tightly closed and the angle of the mouth is retracted in a startling grimace.

Although facial tic and facial spasm are sometimes psychogenic in origin, more frequently an organic cause, such as inflammation or trauma to the nerve, can be assumed. Decompression with neurolysis of the nerve in the bony facial canal by an otologist is the procedure of choice if the cause of the facial tic is thought to be organic. If this is the site of the neural lesion, the tic may completely disappear. If this operation is ineffective, other operative procedures, such as crushing or partial severance of the affected branches of the nerve or anastomosis in the neck of the trunk of the nerve with the hypoglossal nerve may be utilized. Only a few office procedures are available for the management of facial tic and facial spasm.

*Injection of Procaine into the Seventh Nerve at the Stylomastoid Foramen.* A 22 gauge spinal puncture needle is inserted just below the lobe of the ear and in front of the mastoid process. It is directed upward and inward to the stylomastoid foramen (Fig. 338). Injection of 2 or 3 cc. of a 1 per cent solution of procaine results in complete paralysis of the facial muscles and disappearance of the tic or spasm. The chief reason for such a procedure is to familiarize the patient with the disadvantages of facial paralysis. After two or three such injections the patient is in a position to decide whether or not he wants to undergo facial nerve–hypoglossal nerve anastomosis. Following such an operation the patient has complete facial paralysis for at least six months and until the regenerating axons of the hypoglossal nerve have reached the motor end plates in the facial muscles.

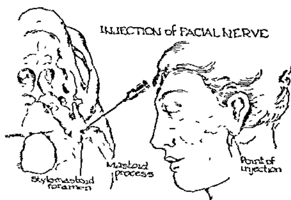



*Figure 338.* Needle inserted to stylomastoid foramen for injection of procaine into facial nerve.

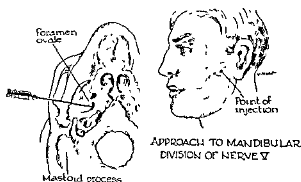



*Figure 336* Needle inserted toward foramen ovale for injection of alcohol into mandibular division of trigeminal nerve

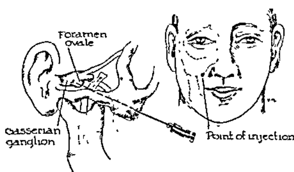



*Figure 337.* Needle inserted through foramen ovale into gasserian ganglion for injection of alcohol.

duced by the procaine hydrochloride. If the nerve is not pierced by the needle on the first attempt, the operator is forced to probe in that neighborhood until he does strike the nerve. Roentgenograms of the skull are of help when the operator is having difficulty in locating the nerve with the point of the needle. Proper injection of the maxillary division often provides relief for a year or longer.

*Alcoholic Injection of the Mandibular Division.* The spinal puncture needle is inserted into the cheek just below the zygomatic notch. The point of the needle is directed medially and slightly posteriorly (Fig. 336). The base of the skull in the region of the foramen ovale is encountered at a depth of about 4.5 cm. If the nerve is pierced by the point of the needle, pain is experienced in the lower jaw, lower lip or tongue. A few drops of procaine injected at this point will result in anesthesia of the lower lip and half the tongue. This is followed by the slow injection of 1 cc. of a 95 per cent solution of alcohol.

*Alcoholic Injection of Gasserian Ganglion.* Although satisfactory injection of the gasserian ganglion results in a permanent cure of trigeminal neuralgia the procedure is dangerous and painful. After a preliminary injection of morphine, a spinal puncture needle, 10 cm. long, is pushed through the skin of the cheek just below the malar bone on a vertical line with the outer canthus of the eye and pointed posteriorly, medially and superiorly (Fig. 337). The goal is to pass the point of the needle through the foramen ovale so that its point eventually lies among the cells of the ganglion. To accomplish this the needle must be inserted about 1 cm. after it enters the foramen ovale. It is extremely important to make sure that the point of the needle does not extend beyond the ganglion to the subarachnoid space. If alcohol diffuses through the subarachnoid space, multiple cranial nerve palsies can result. If cerebrospinal fluid is obtained on aspiration with the syringe, the needle should be withdrawn millimeter by millimeter until the flow of fluid ceases The secret of a successful injection, once the needle is in the proper position, is the slow injection of absolute alcohol. A 1 cc. syringe should be used and the alcohol injected one drop at a time. It is desirable to spend 30 minutes or more for the injection. The development of anesthesia of the face should be carefully followed by repeated testing with a pin point.

### GLOSSOPHARYNGEAL NEURALGIA (NINTH NERVE NEURALGIA)

Glossopharyngeal neuralgia, the exact counterpart of neuralgia of the trigeminal nerve, is characterized by excruciating attacks of lancinating pain in the region of the tonsil. The pain may be confined to this part of the pharynx or may shoot up toward the ear. The tonsillar region constitutes the trigger zone and, consequently, swallowing initiates an attack. Patients learn to tilt the head to the opposite side while swallowing to avoid stimulation of the trigger zone.

*Pontocainization of the Trigger Zone.*

should be repeated daily for several days. Injections can then be given weekly for several weeks. If a patient is seen a week or more after the onset of Bell's palsy, several injections at weekly intervals may possibly be beneficial.

Rarely a patient has two or more attacks of Bell's palsy on the same side. If a patient is seen during a second attack, he should be referred to an otologist for surgical unroofing of the facial canal. Even patients seen during their first attack should be referred to an otologist for consideration of this procedure, if electrical testing after five weeks shows complete reaction of degeneration.

During the first two or three months of Bell's palsy it is theoretically desirable to support the sagging facial muscles with some type of splint.

Although in most patients Bell's palsy clears up completely within five weeks to five months, a small group of patients recover only partially or not at all. Those with incomplete recovery from facial paralysis should be referred to a plastic surgeon. Several surgical methods are available for the support of the drooping corner of the mouth and the wide open palpebral fissure.

If a patient fails to show any evidence of recovery from facial paralysis in twelve months, an otologist should unroof the facial canal and insert a nerve graft. Should this procedure fail, the neurosurgeon should expose the facial nerve and the hypoglossal nerve in the neck near the angle of the jaw and anastomose the central end of the hypoglossal nerve with the distal end of the facial nerve.

Electrical stimulation of the paralyzed muscles is a useful adjunct in the office treatment of Bell's palsy. The paralyzed muscles of the face can be kept in good condition by stimulating the appropriate motor points with any device that provides galvanic and faradic current. The muscles can be made to contract with a galvanic current so that the eye will close or the angle of the mouth will be retracted. Although this is slightly painful, the average patient will accept 10 minutes of stimulation three times a week for two or three months. Theoretically such exercising of the weak or paralyzed muscles will lead to more complete if not more rapid recovery.

In patients with Bell's palsy, conjunctivitis and even keratitis may develop because of their inability to blink or close the eye and keep its surface moist. Drops of mineral oil and bandaging of the eye usually take care of the situation. Rarely is it necessary to suture the lids together.

### OCCIPITAL NEURITIS

Severe pain in the back of the neck and head is usually diagnosed as occipital neuritis or neuritis of the greater or lesser occipital nerves. It is unlikely that this condition is ever a true toxic or inflammatory condition of these nerves. In most cases it is probably due to irritation or constriction of the nerves by muscle, fascia or arthritic changes in the upper cervical spine. The pain is more often unilateral than bilateral. It may be due entirely to nervous tension with tightening cervical musculature. It not infrequently follows injury to the neck or back of the head.

A simple and often effective method of treatment is infiltration of procaine into the tissues at about the level of the hairline of the neck. After the skin and the hair of the back of the head and neck at the level of the mastoid processes have been cleansed, several wheals are made with procaine, a hypodermic needle being used. A 22 or 24 gauge needle is then inserted until the base of the skull is encountered (Fig. 340). The needle is slowly withdrawn as 10 cc. of procaine is injected. The diffusing procaine reaches the occipital nerves, and the scalp of the posterior half of the head on the same side becomes anesthetic. Patients who profit by this empirical dissemination of procaine into muscles and nerves invariably return for further injections whenever the symptoms recur.

Another useful treatment for occipital neuritis and other pains in the occipital region is stretching the neck with a canvas head halter. The patient is put on the treatment table in the supine po-

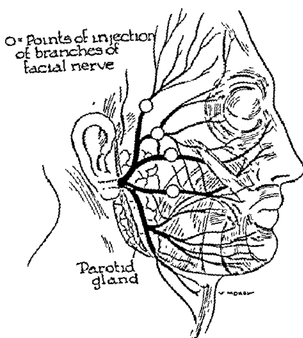



*Figure 339.* Points at which branches of facial nerve can be injected with alcohol.

*Alcoholic Injection of the Seventh Nerve at the Stylomastoid Foramen.* If decompression of the seventh nerve in the bony facial canal has failed to relieve the facial tic or spasm and if the patient does not want to undergo facial nerve–hypoglossal nerve anastomosis, some temporary relief can be obtained by damaging the nerve at the stylomastoid foramen with alcohol. The ideal result, not always obtainable, is partial paralysis—that is, general weakness of the entire facial musculature—which may be obtained by injection of only a few drops of a 50 per cent solution of alcohol about the nerve near its exit from the skull. When such general weakness is obtained, perhaps after several cautious injections on different days, the involuntary movements may be largely eliminated and yet the patient may still be able to close the eye. This procedure could be repeated over a period of years.

*Alcoholic Injection of the Peripheral Branches of the Seventh Nerve.* If neither decompression of the seventh nerve in the bony facial canal nor seventh nerve–hypoglossal nerve anastomosis is planned, the smaller branches of the facial nerve may be injected with alcohol to decrease the twitching of facial muscles. The facial nerve divides immediately before or after emerging from the parotid gland into a fanlike group of branches which are distributed from the frontalis muscle above to the platysma below. A hypodermic needle is inserted through the skin and subcutaneous tissues to the general region of the branch of the nerve whose temporary destruction is desired (Fig. 339). If 0.5 cc. of a 1 per cent solution of procaine paralyzes the muscles involved, 1 cc. of a 50 per cent solution of alcohol is injected to make the paralysis more lasting. If, for example, the spasm or twitching is limited largely to the orbicularis oculi, the alcohol is injected at one or two points about 2 cm. lateral to the external canthus of the eye.

#### BELL'S PALSY[15]

Although there are many causes for facial paralysis of the peripheral type (seventh nerve paralysis), such as tumors of the parotid gland, stab wounds in the region of the parotid gland and skull fractures, by far the commonest is the spontaneous facial paralysis called Bell's palsy. The cause is unknown; however, a prevalent theory is that there is swelling of the seventh nerve within the facial canal of the temporal bone. As the facial nerve fits tightly in this bony canal, it is not surprising that an experience as simple as exposure to a cold draft can result in swelling of the nerve and pressure ischemia.

Although numerous medical measures are available for the amelioration of Bell's palsy, including dehydration of the patient and administration of cortisone or large doses of vitamin $B_{12}$, there are few surgical procedures of value during the early stages of the disease. One of these is infiltration of the stellate ganglion or the cervical sympathetic chain with procaine hydrochloride. It is believed by some that this might decrease the edema of the seventh nerve in the facial canal and lead to improvement in the blood supply of the nerve. If a patient is seen within a few days of the onset of Bell's palsy, interruption of the sympathetic impulses with procaine (see p. 48) is probably worthwhile. This

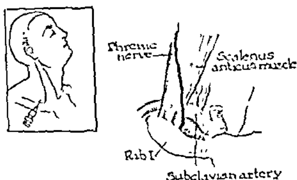



Figure 341. Needle inserted to scalenus anticus muscle for injection of procaine into the muscle or into the phrenic nerve.

this was originally designed as a diagnostic test, it is therapeutically beneficial in certain cases.

### HICCOUGH[18, 19]

Occasionally hiccough persists for several days or even for many weeks. Sometimes it can be relieved by injection of procaine hydrochloride into one or both phrenic nerves. It is probably safe to inject procaine into both phrenic nerves. Since only one side of the diaphragm may be involved in hiccough, fluoroscopy should be done before the physician decides which nerve to inject.

The phrenic nerve is injected 2 cm. above the clavicle where it lies on the anterior surface of the scalenus anticus muscle. After the scalenus anticus muscle is palpated with the thumb, the skin is sterilized and a long hypodermic needle is inserted directly into the muscle (Fig. 341). Ten cubic centimeters of procaine is slowly injected as the needle is gradually withdrawn. Some of the procaine is certain to come in contact with the phrenic nerve as the point of the needle is withdrawn from the muscle. If procaine injections relieve the hiccough only temporarily, the injections can be abandoned in favor of phrenic nerve crushing as a hospital procedure.

### SPASMODIC TORTICOLLIS

Spasmodic contraction of the cervical muscles (spasmodic torticollis) is a chronic and embarrassing condition which is predominantly one-sided although there is usually some involvement of the contralateral cervical muscles. Consequently, interruption of a single nerve or severance of a single muscle never completely corrects the condition. Nevertheless, the sternocleidomastoid muscle on one side is often the one that plays the major role in the movements of the head. For this reason, it is customary to sever the nerve supply to the sternocleidomastoid muscle (spinal accessory nerve) as a first step in the surgical treatment of this disease. The more major step consists in high cervical laminectomy with severance of the motor roots of the upper three cervical nerves.

It is sometimes helpful to paralyze temporarily the affected sternocleidomastoid muscle with procaine in order to enable the patient as well as the surgeon to decide whether or not sectioning of the nerve supply to the muscle is advisable. To do this, 20 to 40 cc. of procaine solution can be injected into the tense muscle at several different levels. If the initial site of injection is just above the mid part of the muscle, the nerve trunk may receive enough procaine to result in flaccid paralysis of almost the entire muscle.

### HERPES ZOSTER[20, 21]

In children and young people, herpes zoster of any part of the body is a disease of little consequence because the painful stage lasts but a few days or a few weeks. However, in people past the age of 50 years the pain may persist for many months or several years. In elderly patients herpes zoster is sometimes a cause of death because persistence of the severe pain leads to exhaustion, mental depression, drug addiction and general debility. Unfortunately, neither a medical nor a surgical cure for postherpetic pain has yet appeared. Severance of the peripheral or spinal nerves is almost always ineffective and cordotomy is usually not beneficial. Even bilateral prefrontal lobotomy is far from reliable as a remedy. Complete removal of the scarred and painful area of skin has not proved to be entirely satisfactory. Hundreds of medical remedies, including vitamin $B_{12}$, antibiotics and cortisone,

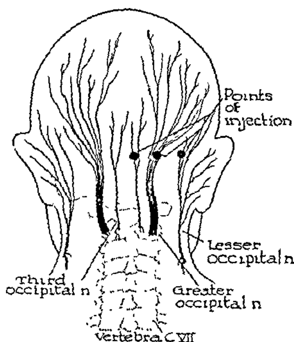



*Figure 340* Location of occipital nerves.

sition, and a 5-pound weight is attached to the head halter and left on for one hour. Patients who profit from this will buy a halter for home use.

Severe occipital pain which does not respond to these measures or to prolonged immobilization in a cervical brace is sometimes due to pinching of one or both second cervical nerve roots as they pass between the arches of the atlas and axis. If this diagnosis can be fairly well established by ruling out platybasia and tumor in the foramen magnum, high cervical laminectomy with section of the second cervical roots is indicated. A simpler procedure that relieves most patients is section of the greater and lesser occipital nerves in the posterior occipital region.

### TEMPORAL ARTERITIS[16]

Temporal arteritis is a disease of unknown etiology, characterized by severe pain in the temporal region, which is usually unilateral but may be bilateral On palpation the involved artery feels tortuous, firm and tender. Occasionally, the skin overlying the artery is inflamed. Sometimes the patient complains of systemic symptoms, such as moderate fever and chills, generalized muscular aching and easy fatigability. Visual impairment occurs in about one-third of these patients. The disease is commonly benign and usually runs its course in a matter of a few months; nevertheless, some fatalities have been reported. The usual microscopic picture is that of arteritis and chronic periarteritis with thickening of the intima.

Treatment consists in administration of cortisone or a similar corticosteroid as soon as possible. The temporal pain can be relieved by injection of procaine around the artery or section of the artery.

*Procaine Injection.* With a hypodermic needle 10 or 15 cc. of a 1 per cent solution of procaine is injected into the skin close to the temporal artery, which is tortuous and usually visible or at least palpable. If the diagnosis is correct, dramatic relief promptly results. A single injection may relieve the pain permanently or other attacks may occur days or weeks later Infiltration of procaine may be repeated whenever pain occurs. However, in troublesome cases it is best to make an incision 2.5 cm. long immediately over the artery, mobilize it extensively, and remove a section. This, incidentally, provides opportunity for histologic confirmation of the diagnosis.

### SCALENUS ANTICUS SYNDROME[17]

Scalenus anticus syndrome is characterized by pain, paresthesias and circulatory embarrassment in the upper extremity. A tight or spastic scalenus anticus muscle can cause any degree of compression of the lateral cord of the brachial plexus and the subclavian artery. The clinical picture depends upon the degree of compression of the nerves and vessels. Since one of the major causes of scalenus anticus syndrome is spasm of the muscle secondary to rupture of one of the lower cervical disks, this possibility should be kept in mind in all cases. In addition to such measures as antispasmodic drugs and physical therapy, a certain degree of relief may be obtained by injection of procaine into the tight and easily palpable scalenus anticus muscle at a point just above the clavicle (Fig. 341). Whereas

needle is pointed 10 to 20 degrees posteriorly and downward when it is inserted through the fontanel 3 cm. from the midline. It is inserted a few millimeters at a time and the stylet withdrawn. When the ventricle is eventually reached, the exact thickness of this part of the brain becomes known. In advanced hydrocephalus the ventricle is 1 cm. or less from the surface of the skin; in such cases the parents can be told that hospitalization for further studies and surgical treatment would be of no avail. If there are 2 or 3 cm. of brain between the ventricle and the fontanel, further study is justified.

## SCALP INJURIES

Lacerations of the scalp can be adequately treated in the office or outpatient clinic. However, if there is evidence of an underlying fracture, the diagnosis is no longer laceration of the scalp but compound fracture of the skull, and hospitalization is indicated in most cases. Extensive lacerations and partial avulsions of the scalp should also be treated in a hospital.

*Minor Lacerations.* Small and superficial lacerations of the scalp do not require extensive preparation such as shaving. The wound should be cleansed with cotton applicators and carefully inspected. Approximation of the skin edges with one or two sutures of cotton, silk or other material is the only treatment needed. A dressing is impractical. Occasionally, it is sufficient to approximate the cutaneous edges by tying together several of the hairs immediately adjacent to the wound.

*Major lacerations* are those which extend through the deep fascia (galea aponeurotica). They may be short, as in stab wounds, or of any length. Since bleeding has almost always stopped by the time a laceration comes to the attention of the surgeon, the first step is to shave the scalp for a distance of 2 cm. around the wound. The second step is careful cleansing of the wound with soap and water, cotton applicators being used. It is also desirable to irrigate the wound thoroughly with saline solution. If the cleansing initiates bleeding, an assistant must exert fingertip pressure close to the edges of the wound. The assistant is also able to spread the wound at the same time. If an underlying comminuted or depressed fracture is seen, it is best to suture the laceration but the patient should be admitted to the hospital for observation and probably for more extensive surgical care. Fragments of bone should not be removed in the office or home. Such a patient should be sent to the hospital for reopening of the scalp wound, débridement of the skull, and evacuation of extradural and subdural hematomas if present. If the bone or deeper structures are bleeding profusely, the scalp wounds should be left open and the patient sent to a hospital operating room.

After dirt and other foreign bodies have been removed from the wound in the case of a simple laceration of the scalp, strings of nonviable tissue can be snipped away with the scissors. However, in these days of antibiotics extensive débridement is unnecessary. If the laceration is long, the deep fascia should be closed with interrupted sutures of cotton or silk. On the other hand, if the laceration is short and the scalp swollen, closure of the deep fascia is technically difficult or impossible and should not be attempted. In such cases the cutaneous edges should be approximated with interrupted sutures of cotton, silk or other material. If only one layer of sutures is used to close a laceration, it is proper to have the sutures incorporate the deep fascia as well as the skin. When the edges of the wound have been approximated, the bleeding stops. It is not necessary and is, in fact, usually impossible to ligate the severed vessels in the scalp. The dressing should be cut to the shape of the shaved area and fastened in place with collodion. In contrast to wounds in most parts of the body the superficial sutures used in closing lacerations of the scalp should be removed in 48 hours. The blood supply of the scalp is so abundant that wound infection or cellulitis practically never occurs if the laceration has been properly cleaned and

have been used with little benefit. Even irradiation has been tried.

The two office procedures which give some relief are procaine injection of the paravertebral sympathetic chain and procaine infiltration of the painful cutaneous area. The technique for procaine infiltration of the cervical, thoracic and lumbar sympathetic ganglia is described in Chapter 4.

Local infiltration of procaine is carried out in the following manner. With a skin pencil the painful area is outlined to the patient's satisfaction. After the skin has been sterilized, up to 200 cc. of a 0.5 per cent solution of procaine is injected at several dozen different points with a hypodermic needle. This amount of fluid, when injected with force, causes pronounced elevation of the skin throughout the area outlined. The procedure may be repeated weekly if beneficial.

### HYDROCEPHALUS[22, 23] AND SUBDURAL HEMATOMA IN INFANTS

Although infants with bulging fontanels and enlarged heads should be studied and treated in a hospital, they are usually first seen in the office and may well receive preliminary investigation there. The baby with an enlarged head may have hydrocephalus, bilateral subdural hematomas, brain tumor or cerebral abscess It is exceedingly important to recognize a subdural hematoma as quickly as possible because such cases offer a good prognosis. The principal test in differentiating chronic subdural hematoma from other conditions that cause enlargement of the head is aspiration of the subdural space by needle through the fontanel. After the region of the fontanel has been shaved and sterilized, a 20 gauge spinal puncture needle is passed through the skin near the lateral angle of the fontanel (Fig. 342). The point of the needle is slipped under the free edge of the parietal bone so that it hugs the undersurface of that bone. As it is more or less impossible to slip the needle between the skull and the closely adherent dura, the point of the needle is almost certain to be in the subdural or

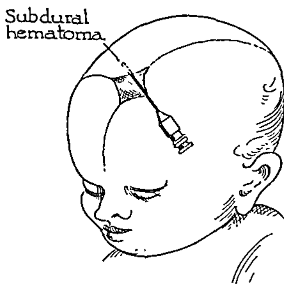



*Figure 342.* Aspiration of liquid subdural hematoma through lateral angle of fontanel

subarachnoid space. If a large liquid hematoma is present, the subdural space will be one to several cubic centimeters in depth and no trouble will be had in collecting from 10 to 30 cc. of fluid, which varies in color from pale yellow to chocolate brown. If a subdural hematoma is encountered, the stylet should be replaced in the needle *before* more than 5 cc. of the hematoma fluid has been removed, and a second needle should be introduced into the subdural space on the other side of the head.

Cures of bilateral subdural hematoma after repeated aspirations over a period of weeks have been reported. However, most neurosurgeons prefer to remove the hematoma and the neomembrane that encloses it through an osteoplastic flap.

If a subdural hematoma is not present, the exploring needle will enter the subarachnoid space, permitting the escape of clear cerebrospinal fluid. If the point of the needle punctures a small vessel on the surface of the cortex, there will be streaks of fresh blood in the escaping fluid. If chronic subdural hematoma has been ruled out by this procedure, the examiner may wish to reinsert the needle directly into the ventricle to verify the fact that the ventricle is enlarged and contains clear cerebrospinal fluid, and to determine the thickness of the brain between the roof of the ventricle and the surface of the cortex. To do this the

*closes no underlying fracture of the skull,* the repair is carried out in the office as described in the preceding section.

4. *Spinal puncture should not be performed as an office procedure* and not routinely as a hospital procedure for acute head injuries.

*Associated Injuries.* The most important part of an examination of a patient unconscious because of a head injury is the search for an obstructed airway, a ruptured spleen, liver or kidney, hemopneumothorax and fractures of the extremities. Unconscious patients may die from an unrecognized ruptured viscus or from fat embolism secondary to unrecognized fracture of a long bone.

*Surgical Shock.* Inasmuch as injuries of the brain and fractures of the skull do not produce shock, the existence or development of shock should be explained on some other basis, such as excessive bleeding from a scalp laceration, exposure to cold or injury of some other part of the body. To combat sudden shock pending transfer to a hospital the foot of the stretcher or examining table should be elevated and plasma, plasma expanders, saline or glucose should be given intravenously.

#### PERIPHERAL NERVE INJURIES[24-26]

Surgical repair of a lacerated peripheral nerve requires hospitalization, but initial evaluation and treatment of such injuries are performed in the office or outpatient clinic. The history should include the time of the injury, the exact site of entrance and exit, the object that produced the injury, the sensation felt when the injury occurred and the position that the patient was in when injured.

The wound should be examined. In open wounds, four types of nerve injury may occur. The nerve may appear relatively normal or it may be discolored or swollen. It may be completely divided and each end may be macerated, in which case there will be a varying amount of hemorrhage in the divided nerve ends either at the immediate end or for varying distances from the point of section. If the nerve is partially divided, intact fascicles may herniate through the lateral epineural lacerations. Also, they are edematous at the point of maximum trauma. The amount of actual damage in a partially sectioned nerve or a contused or swollen intact nerve segment is impossible to evaluate accurately on inspection.

In a closed nerve injury with complete paralysis, it is not possible to determine whether the nerve has been contused or divided. However, complete interruption of a nerve, whether physiologic or anatomic, will reveal: (1) complete paralysis of all muscles supplied by the nerve distal to the lesion, (2) loss of objective sensibility in the domain of the affected nerve, (3) atrophy of the paralyzed muscles after some weeks, (4) absence of pain on pressure applied to the nerve trunk below the lesion, and (5) complete reaction to degeneration on electrical testing. To evaluate paralysis of muscles supplied by a particular nerve, great care must be taken in the analysis of all muscle movements. Careful measurements and precise records are necessary. Usually with loss of motion a characteristic position deformity is produced, such as wrist drop, foot drop, clawed fingers or ape hand. Lesions of single nerves result in only partial anesthesia because other nerves overlap the area. After injury of peripheral nerves sensory symptoms may progressively diminish, and at times the loss of sensation to pinprick may be difficult to detect. Severe widespread anesthesia results only from trauma of several nerve trunks of a plexus. After the initial trauma, pain usually is not present with the exception of causalgia. When pain is present, it is usually described as aching, sore, throbbing or burning. It may rarely be a stabbing pain which is aggravated by exercise. The dependent position magnifies it, and as a rule pain is worse at night.

Examination of an injured nerve should include testing of voluntary motion, sensation, reflexes and reaction of the muscles and nerve to electrical stimulation.

Injuries of the brachial plexus are

closed within 24 hours. Sulfonamides should not be placed in a laceration before closure. One-half million units of penicillin can be injected intramuscularly at the end of the operation but only if the wound is more than 12 hours old or extensively contaminated. Although it is customary to give tetanus antitoxin or toxoid for lacerations of the scalp, this is probably an unnecessary precaution. On the other hand, if the laceration is in the region of the temporalis or suboccipital muscles and if these muscles have been damaged, it is important to give tetanus and gas gangrene antitoxin. At the time of repair of such a wound nothing is gained by placing sutures in these muscles.

Whereas anesthesia is not necessary if only one or two sutures are to be placed in the scalp to close a small laceration, more extensive suturing requires infiltration of the scalp with a 1 per cent solution of procaine. After the wound has been cleansed, the procaine is injected through a hypodermic needle which has been inserted directly into the cut surface of the scalp. Administration of the anesthetic is thus less painful and it incidentally controls bleeding by distending the scalp with fluid.

***Burns*** of the scalp are treated no differently from those elsewhere on the surface of the body. The head is clipped and shaved, thoroughly cleansed with soap and water and covered with a thin layer of gauze which has been impregnated with some antibacterial substance. A pressure dressing is then applied.

***Sebaceous cysts*** of the scalp can be removed in the office but two pairs of hands are required. After adequate shaving of the scalp and cleansing of the skin, a single sterile towel in the center of which a small hole has been cut is carefully applied. Procaine is injected with a hypodermic needle, which is inserted to the bone and slowly withdrawn during the injection. The edges of the towel can be fastened to the anesthetized scalp with four small towel clips or with sutures. A straight incision 3 or 4 cm. long is made over the apex of the cyst. Bleeding from the edges of the scalp is controlled by digital pressure applied by the assistant. Incidentally, this digital pressure improves exposure of the cyst, which can be quickly mobilized by blunt dissection. The cyst is grasped with an Allis forceps, its few attachments are snipped with scissors and the delivery has been completed. No vessels are ligated during the operation. Several hemostats are applied to the cut edges of the deep fascia and the handles are laid away from the wound. This maneuver brings the deep fascia toward the surface and controls all bleeding. A layer of interrupted sutures of cotton or silk is used to close the deep fascia but they are not tied until all have been put in place. The hemostats are removed and the assistant again applies digital pressure near the edge of the wound to control bleeding. The deep sutures are tightly tied, bringing the edges of the galea together. Interrupted sutures are also used to close the skin. A dressing the size of the shaved area is fastened in place with collodion. The sutures should be removed within 48 hours.

### SKULL AND BRAIN INJURIES

In rural areas patients with injuries of the skull and brain are frequently taken to private homes or to physicians' offices. Some of the office procedures pertinent to such problems are:

1. *If a patient is unconscious from a head injury,* it should also be assumed that he might have a *fracture dislocation of the cervical spine* and should be handled accordingly.

2. *Compound Fractures of the Skull.* All wounds of the scalp should be carefully inspected, cotton swabs being used to remove the blood. If a comminuted or depressed fracture is seen, a diagnosis that requires hospitalization has been established and nothing further should be done. The wound should not be cleansed; the scalp should not be shaved; sulfonamides should not be placed in the wound. A pressure dressing *should be* applied and tetanus antitoxin or toxoid and penicillin should be given intramuscularly.

3. *If inspection of a scalp wound dis-*

*closes no underlying fracture of the skull,* the repair is carried out in the office as described in the preceding section.

4. *Spinal puncture should not be performed as an office procedure* and not routinely as a hospital procedure for acute head injuries.

*Associated Injuries.* The most important part of an examination of a patient unconscious because of a head injury is the search for an obstructed airway, a ruptured spleen, liver or kidney, hemopneumothorax and fractures of the extremities. Unconscious patients may die from an unrecognized ruptured viscus or from fat embolism secondary to unrecognized fracture of a long bone.

*Surgical Shock.* Inasmuch as injuries of the brain and fractures of the skull do not produce shock, the existence or development of shock should be explained on some other basis, such as excessive bleeding from a scalp laceration, exposure to cold or injury of some other part of the body. To combat sudden shock pending transfer to a hospital the foot of the stretcher or examining table should be elevated and plasma, plasma expanders, saline or glucose should be given intravenously.

### PERIPHERAL NERVE INJURIES[24-26]

Surgical repair of a lacerated peripheral nerve requires hospitalization, but initial evaluation and treatment of such injuries are performed in the office or outpatient clinic. The history should include the time of the injury, the exact site of entrance and exit, the object that produced the injury, the sensation felt when the injury occurred and the position that the patient was in when injured.

The wound should be examined. In open wounds, four types of nerve injury may occur. The nerve may appear relatively normal or it may be discolored or swollen. It may be completely divided and each end may be macerated, in which case there will be a varying amount of hemorrhage in the divided nerve ends either at the immediate end or for varying distances from the point of section. If the nerve is partially divided, intact fascicles may herniate through the lateral epineural lacerations. Also, they are edematous at the point of maximum trauma. The amount of actual damage in a partially sectioned nerve or a contused or swollen intact nerve segment is impossible to evaluate accurately on inspection.

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Examination of an injured nerve should include testing of voluntary motion, sensation, reflexes and reaction of the muscles and nerve to electrical stimulation.

Injuries of the brachial plexus are

usually divided into lesions of the trunks and cords. However, if the entire brachial plexus is involved, there is extensive loss of function of the entire extremity. In lesions of the upper trunk the deltoid, biceps and brachioradialis muscles are paralyzed. If the middle trunk is damaged, the extensors of the arm and forearm are weakened but the brachioradialis is not affected. Sensory deficit in this instance consists of a small strip of anesthesia on the back of the forearm and radial aspect of the dorsum of the hand. Injuries to the lower trunk create a combined "ulnar and median paralysis" that is manifested by weakness of the flexures of the hand and fingers. Sensory deficiency is detected along the ulnar side of the arm, forearm and hand. If the lateral cord of the plexus is damaged, the biceps and all the muscles supplied by the median nerve except the intrinsic muscles of the hand will be paralyzed. A small sensory deficit can usually be found on the radial aspect of the forearm. A medial cord injury is comparable with combined ulnar and median paralysis with sensory loss along the medial border of the arm, forearm and hand. Damage to the posterior cord affects the muscles supplied by the radial, axillary and suprascapular nerves and causes difficulty in elevating the extremity and weakness of the extensors.

As a rule, injuries of the median nerve may be quickly detected if pinching the tip of the index finger fails to cause pain and the patient is unable to flex the distal phalanx of the index finger. The ulnar nerve has been injured if pinching the tip of the little finger produces no sensation, the patient is unable to adduct the little finger, and he can approximate the fingers only weakly.

Damage of the radial nerve above the elbow is detected by inability to dorsiflex the hand at the wrist or fingers at the metacarpophalangeal joints. If the lesion is below the elbow, the wrist drop may be incomplete. If the musculocutaneous nerve is injured, the patient will not be able to contract the biceps brachii muscle and a small sensory deficit may be found in the region of the deltoid. Injury of the sciatic nerve causes paralysis of all the muscles below the knee and loss of sensation on the outer side of the leg and lateral three-fourths of the foot. Damage to the common peroneal nerve or its main branch, the deep peroneal nerve, will cause foot drop and will prevent the patient from dorsiflexing the foot or toes. The sensory deficit usually encountered is over the dorsum of the foot and outer side of the leg. If the deep peroneal nerve is divided in the distal part of the leg, the sensory deficit will be in the region between the great and second toe. Injury to the tibial nerve will result in inability to plantarflex the toes and ankle and anesthesia of the sole of the foot and plantar surface of the toes.

***Treatment.*** Primary or emergency suture of peripheral nerves is followed by a high incidence of failure of regeneration. Consequently, suture should be deferred in all but the cleanest and most uncomplicated cases. The primary goal at the time of injury is to convert an open contaminated wound into a closed clean wound. The wound is mechanically cleansed and débrided, and hemorrhage is controlled. Damage to specific tissues is assessed with as little dissection as possible. Divided nerve ends may be gently approximated with delicate through-and-through sutures in order to prevent retraction and to aid in location of the point of injury later at the time of repair. Tagging the contused end of the nerve with a metal clip at times aids in locating the damaged end at the time of repair. After three to six weeks the extent of the peripheral nerve injury is much more apparent and repair may be accomplished under more favorable circumstances and with better results.

Electromyography and electrical stimulation of peripheral nerve and muscle are two valuable procedures in the study of nerve injuries. Electromyography consists in studying the variations of electrical potential of a skeletal muscle. By means of this procedure one can detect minimal residual innervation as well as the earliest evidence of reinnervation,

both of which are important in the management of nerve injuries. Electromyographic evidence of reinnervation will precede clinical evidence of return of function by several weeks. Electrical stimulation of a peripheral nerve is a useful test of the function of the peripheral neuromuscular system and is of definite value in determining physiologic continuity of a nerve.

### SPINA BIFIDA[22, 23]

Many newborns with meningoceles and myelomeningoceles should be operated on during the first week of life because of escaping cerebrospinal fluid and the threat of meningitis. However, many meningoceles and myelomeningoceles do not seep cerebrospinal fluid and are therefore not suitable for immediate surgical treatment. The operation can be postponed for weeks or many months. A few myelomeningoceles may never require operation.

Meningoceles and myelomeningoceles covered by a thin but intact membrane should be protected against rupture, and an attempt should be made to stimulate thickening of the covering membrane. Cleansing the lesion several times a day with ether and with soap and water is of basic importance. Painting the membrane with a dilute solution of some caustic stimulates thickening of the membrane. The pulling together of the skin margins with adhesive tape takes the tension off the membrane and permits it to thicken. When adhesive strapping is employed, a small dressing no larger than the membrane can first be applied or the membrane can be invaginated so that no dressing is required under the adhesive tape. The end result in successful cases is a mass of heavy scar tissue which requires no attention other than daily cleansing with soap and water. Operation can thus be avoided.

If a myelomeningocele is large and covered with a thin membrane, surgical treatment is obviously needed. Temporarily the lesion is protected with petrolatum and a large "doughnut" made of gauze. The outer dressing should be covered with a sheet of waterproof material which is fitted closely to the skin.

In a high percentage of infants with lumbar myelomeningocele, hydrocephalus eventually develops. Usually the hydrocephalus is due to an associated malformation in the region of the foramen magnum, namely, the Arnold-Chiari malformation. Consequently, every newborn with spina bifida is potentially hydrocephalic. Accordingly, systematic attention must be given to measurement of the head, inspection of the fontanel and palpation of the entire head. Several weeks may pass before the examiner is convinced that hydrocephalus is or is not developing.

Since the repair of spina bifida and the surgical treatment of hydrocephalus are hospital problems, little more need be said on the subject here. However, it is well to point out that nothing is gained by repeated aspiration of fluid from the lateral ventricle in the management of hydrocephalus. If anything, this procedure stimulates the production of cerebrospinal fluid.

### MARALGIA PARESTHETICA

Maralgia paresthetica is a sensory mononeuritis involving the lateral femoral cutaneous nerve that is formed by fibers of the second and third lumbar roots. The syndrome consists of paresthesias, pain and numbness in the lateral part of the anterior aspect of the thigh as far down as the knee. The paresthesias are described as pricking, tingling, pins and needles, and a tight feeling. Occasionally a burning pain is felt, but numbness may be the primary complaint. Various factors play a part in the production of this condition, but compression of the nerve is thought to account for most cases; infection or toxins cause about one-third of the cases. The anatomic course of the nerve places it in an unusually vulnerable position to be easily injured as it passes between the two reflections of the inguinal ligament and through the fascia lata. Back braces and corsets occasionally are the offending agents. Men are affected three times more often than women. The syndrome may occur during pregnancy. Involve-

ment is usually unilateral. Appreciation of touch, temperature and pain may or may not be diminished. The course of the disease is variable and the complaints may disappear completely in several days or weeks. Removal of corsets, constricting bands or belts provides relief in many cases. Occasionally, it is necessary to section the nerve, free the nerve from constricting scar tissue or open its fascial sheath.

### RUPTURED CERVICAL DISK[27]

Rupture of a cervical disk with resulting nerve root compression causing pain in the upper extremity, pectoral region and suprascapular region is generally a problem for nonhospital management. Only a small percentage of such lesions are sufficiently incapacitating to justify neurosurgical treatment. The symptoms are usually intermittent, and although they recur over a period of several years, they eventually disappear.

The most effective treatment during an acute attack is immobilization of the cervical spine. This can best be accomplished by wearing of a neck brace or by application of traction. The standard neck brace of metal and leather can be employed, but a felt collar is sometimes even more effective. A piece of orthopedic felt about ½ inch in thickness is cut and fitted to the patient's neck so as to provide a high collar. It should reach the mastoid process and the mandible. It is then enclosed in stockinet or other soft durable material. After it is put in place, it is closed with strips of adhesive tape. Although this type of collar does not actually prevent movements, it is a constant reminder to the patient to avoid moving his neck.

*Head Halter Traction.* General stretching of the neck by means of a canvas head halter and an 8 to 20 pound weight is helpful in a high percentage of patients with cervical disk symptoms. Although traction may not actually widen the intervertebral foramen, it does immobilize the neck and overcomes muscle spasm. It is well to give the first treatment in the office. When the patient is familiar with the application of and the principle of the head halter, he can be provided with one for home use. Use of the halter for two hours twice or even once a day is often sufficient to keep the symptoms in abeyance.

*Myelography* for confirmation of a diagnosis of ruptured cervical or lumbar disk should not be performed until a decision has been made to operate. Consequently, myelograms when needed are usually made in a hospital on the day prior to operation. However, there is no reason why myelography cannot be carried out in the office or an outpatient clinic. A lumbar puncture is done with an 18 gauge needle with the patient lying on his side. After attaching the water manometer and observing the pressure, the operator applies bilateral jugular compression for a period of 10 seconds. If there is a rapid rise and fall with compression and release of the jugular veins, the possibility of a cord tumor simulating a ruptured cervical disk is decreased. Spinal fluid is removed for the cell count and the total protein determination. Following this, 12 cc. of Pantopaque is injected and the needle is not withdrawn. Fluoroscopy is carried out with the patient prone and with the neck extended as much as the muscle spasm will permit. As the head end of the table is lowered, care should be taken to insure that as little oil as possible flows into the cisterna magna. After fluoroscopy and the making of spot films the Pantopaque is removed by tilting the table to pool the oil at the point of the needle for slow aspiration with a syringe. Obviously, it is desirable when possible to inject as well as remove the Pantopaque with the patient on the fluoroscopic table in order to avoid an additional spinal puncture.

*Cervical Diskography.* See p. 510.

### RUPTURED LUMBAR DISK[28]

In contrast to rupture of a cervical disk, a fairly high percentage of patients incapacitated with chronic low back pain and sciatica due to rupture of a lower lumbar disk require operation. The most effective nonsurgical treatment for low

back pain and sciatica is bed rest at home. Application of traction to one or both of the lower extremities is sometimes helpful.

The office procedures that are sometimes of value in diminishing or terminating an attack of lumbago, sciatica, or both, are:

1. *Procaine Injections.* For somewhat obscure reasons infiltration of the spastic paravertebral muscles with procaine sometimes gives considerable relief. The injections can be repeated several times during each episode. Injection of procaine or other substances directly into the sciatic nerve is not recommended.

2. *Epidural Injection of Saline or Procaine.* Prior to the discovery of ruptured intervertebral disk as the cause of at least 90 per cent of all cases of sciatica, many patients obtained at least temporary relief from the forceful injection of saline or dilute procaine into the epidural space via the sacral hiatus. With the patient in the prone position and a pillow under the pelvis, the sacral hiatus is identified by palpation with the finger. After cleansing of the overlying skin, a wheal of procaine is made with a hypodermic needle. A 22 gauge spinal puncture needle or an intravenous needle is inserted through the sacral hiatus into the sacral canal. If the needle is pointed toward the patient's head during insertion, it will not scrape the walls of the sacral canal. The needle should not be inserted more than 3 or 4 cm. because the tip of the dural sac extends down into the sacral canal for several centimeters. With a 20 cc. syringe normal saline or dilute procaine (0.25 per cent) is injected as rapidly as possible after the operator has made certain that cerebrospinal fluid or blood cannot be aspirated through the needle. Up to 40 cc. can be injected. The fluid so injected fills the sacral canal and extends upwards in the extradural space of the lumbar and thoracic region. The purpose of forceful rapid injection is to compress the dural sac in the hope that the attached lower lumbar nerve roots will be pulled to a slightly different position. If this mechanical measure happens to displace the root which is compressed by a ruptured disk, the relief of sciatic pain will be prompt and perhaps prolonged. The amount of pressure that can be applied to the barrel of the syringe during the injection is determined entirely by the response of the patient. Since the forceful injection increases the intracranial pressure and compresses the intraspinal veins, there are varying symptoms including headache, fear, back pain and perhaps increase in sciatic pain. The patient must be warned that the procedure is painful and he must also be assured that the pain will stop the moment that he insists that the operator release the pressure on the barrel of the syringe.

3. *Myelography.* As described under the heading of ruptured cervical disk, myelography for confirmation of the diagnosis can be performed in the office prior to admission to the hospital for operation. We recommend that 9 cc. of Pantopaque be used for lumbar myelography.

4. *Diskography.*[29, 30] Diskography is the roentgenographic study of an intervertebral disk after injection of a radiopaque medium into the nucleus pulposus of the intervertebral disk. The procedure is performed chiefly on patients with normal myelograms in spite of clinical evidence of a ruptured disk. By this method rupture of the annulus fibrosis of a disk can be positively demonstrated. The disks most frequently studied are the two lower cervical and the three lower lumbar, since most ruptures occur at these levels. The techniques for studying the lumbar and cervical regions are different, since the approach to a lumbar intervertebral disk is through the dural sac, whereas the cervical disk must be entered by the anterior lateral route.

To perform lumbar diskography the skin is prepared and anesthetized as for spinal puncture. No. 18 needles are inserted in the midline between the fourth and fifth lumbar and the fifth lumbar and first sacral posterior spinous processes. A needle is also inserted into the third disk if indicated clinically. A lateral roentgenogram is taken to determine the position of the needle. If the

ment is usually unilateral. Appreciation of touch, temperature and pain may or may not be diminished. The course of the disease is variable and the complaints may disappear completely in several days or weeks. Removal of corsets, constricting bands or belts provides relief in many cases. Occasionally, it is necessary to section the nerve, free the nerve from constricting scar tissue or open its fascial sheath.

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bosis or embolism, cerebro-arterial spasm after angiography, herpes zoster of the upper extremity or face, acute occlusion of the major vessels of the upper extremity and neck, thrombophlebitis, thromboangiitis obliterans of the upper extremity and the shoulder-hand syndrome.

Stellate ganglion block may be performed in the office or hospital. The patient is placed in the supine position with a pillow under the shoulders so that the neck will be hyperextended. The point of injection is 1.5 inches or approximately two fingerbreadths lateral to the midline and the same distance above the clavicle. This point overlies the transverse process of the seventh cervical vertebra and is at the medial border of the sternocleidomastoid muscle. Chassaignac's tubercle of the transverse process of the sixth cervical vertebra is located by having the patient turn his head to the opposite side and palpating for the most prominent transverse process. The seventh cervical transverse process, which is the level of the stellate ganglion, lies approximately 0.5 inch below Chassaignac's tubercle. An intradermal wheal is raised by injection of 2 cc. of a 1 per cent solution of procaine with a 25 gauge needle. A 22 gauge spinal needle is then inserted perpendicular to the table until it touches the transverse process of the seventh cervical vertebra. The depth varies from patient to patient but is seldom more than 1.5 inches. If no bone is encountered or if paresthesias of the brachial plexus are elicited, the needle point is redirected until it touches the transverse process. The needle is withdrawn a few millimeters and aspiration is performed before a test dose of 1 to 2 cc. of the anesthetic solution is injected. If no untoward reaction occurs, such as dizziness or nausea, 10 to 15 cc. of a 1 per cent solution of procaine is slowly injected. The patient should be closely observed for 30 minutes thereafter.

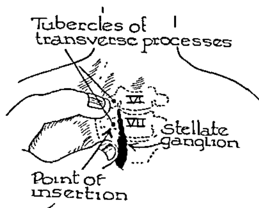



*Figure 345.* Stellate ganglion block. The fingers retract the sternocleidomastoid muscle and carotid sheath laterally to aid insertion of the needle.

The signs and symptoms of sympathetic paralysis occur on the ipsilateral side of the block and consist of ptosis of the eyelid, enophthalmia, a constricted pupil, dilatation of the blood vessels of the sclera and conjunctiva, anhidrosis of the face and arm, and increase in temperature of the arm.

Fortunately, complications are rare. The most frequent is a toxic reaction from the anesthetic. This is usually manifested by a high concentration of the drug in the blood and is detected by drowsiness, incoherent speech, cardiac irregularity, hypotension, dyspnea and twitching of small muscles of the face. Allergy to the drug employed is evidenced by angioneurotic edema, cutaneous wheals, itching, hypotension and asthmatic breathing. Occasionally, pneumothorax occurs on the side of the block, and usually the first indication is pain in the chest. Roentgenographic evidence may be present, depending on the extent of the pneumothorax. Subarachnoid injection may be detected by inability of the patient to breathe, sudden fall in blood pressure and temporary paralysis of the musculature caudal to the block. Occasionally, overflow of the anesthetic agent will anesthetize the brachial plexus, recurrent laryngeal nerve or phrenic nerve. The patient will complain of tingling or numbness of the hand, hoarseness and some difficulty in breathing, which require no treatment.

After a satisfactory stellate block, the facial signs of a Horner's syndrome appear within 2 to 30 minutes and persist for one to four hours. It is possible to block the sympathetic chain creating a Horner's syndrome without blocking the sympathetics to the arm and thorax.

needle is in line with the disk, a No. 26 needle is passed through the large needle into the nucleus pulposus. Another roentgenogram is taken to be certain of its position. If the needle is located satisfactorily, Hypaque sodium is injected into the disk. A normal lumbar disk will take 0.5 cc. to 1 cc., whereas an abnormal disk will take 2 cc. or more. During injection of an abnormal disk the patient will usually feel pain that corresponds to his chronic spinal or radicular pain, or both. The needles are removed after the lateral roentgenograms are taken and anteroposterior and standing views are obtained. These must be made promptly after the injection since the medium is absorbed within 20 minutes.

To obtain a cervical diskogram the skin of the anterolateral aspect of the neck is sterilized; the fingers are used to displace the carotid sheath laterally and the trachea medially. With deep pressure it is possible to palpate the vertebral body. After the skin has been anesthetized, a No. 18 needle is inserted to the spine. A roentgenogram determines whether the point of the needle is against a disk or a vertebral body. After the needle is located properly, a No. 26 needle is inserted through it into the nucleus pulposus. The inner needle should not extend more than 1 cm. past the tip of the larger needle, since cervical disks are small and it is possible to damage the spinal cord by deeper insertion. Anteroposterior and lateral roentgenograms determine the ultimate position of the point. With a 1 cc. syringe, Hypaque sodium is injected under great pressure. A normal cervical disk will take only 0.2 to 0.3 cc. of fluid, whereas an abnormal disk will take 2 cc. or more. During the injection it is important for the patient to describe any localizing discomfort, such as extension of pain into an extremity. Anteroposterior and lateral roentgenograms are made without moving the patient or the needle. A normal diskogram shows an oval-shaped mass of Hypaque in the nucleus pulposus (Fig. 343*a*). If the annulus fibrosis is disintegrated, the Hypaque flows through the crevices and may even escape from the disk (Fig. 343*b*).

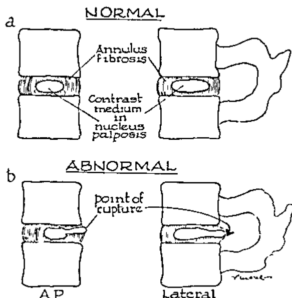



*Figure 343.* *a*, Diagrammatic representation of a normal diskogram. *b*, Diagrammatic representation of an abnormal diskogram revealing posterolateral rupture.

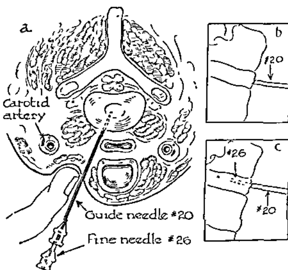



*Figure 344.* *a*, Cross section of the cervical region revealing the needles in position for [illegible] for insertion of contrast medium.

**STELLATE GANGLION BLOCK[31]**

Anesthetization of the stellate ganglion of the cervicodorsal sympathetic chain may be of value in Raynaud's disease, frostbite, causalgia, hyperhidrosis, facial (Bell's) palsy, occlusion of the retinal artery, angina pectoris, cerebral throm-

the patency of the system. Any increase in intra-abdominal and intrathoracic pressure causes a prompt rise of the fluid in the manometer of 30 or more millimeters. If the arachnoid or a nerve root is lying on the opening in the needle, the needle can be rotated slightly. A good way is to rotate the needle 180 degrees.

If the clinical diagnosis is thought to be some type of intracranial disease, the jugular compression test should never be performed. The sole purpose of the jugular compression test is to demonstrate the presence or absence of a tumor in the spinal canal. After the intracranial pressure has been determined with the patient completely relaxed, the manometer is removed and a total of about 6 cc. of cerebrospinal fluid is collected in several sterile test tubes for laboratory study. If the pressure is over 350 mm., it is best to remove only 1 or 2 cc. of fluid for cell count and protein determination. If it is exceedingly high (450 mm.), the needle should be quickly withdrawn. The fluid in the manometer will be sufficient for the cell count.

Spinal puncture is a potentially dangerous procedure if the patient has high intracranial pressure due to tumor, chronic hematoma or brain abscess. In such conditions the midbrain is apt to be impacted at the incisura, or the cerebellar tonsils and medulla may be impacted at the foramen magnum. In such cases, withdrawal of fluid by spinal puncture may lead to further impaction and embarrassment of the blood supply with a fatal outcome in minutes or hours. It may be well to reiterate at this point that the jugular compression test should never be performed unless the examiner is trying to demonstrate the presence or absence of a tumor within the spinal canal.

*Jugular Compression Test.* If the tentative clinical diagnosis is intraspinal disease, the examiner has no particular interest in the pressure but is concerned entirely with the jugular compression test and the obtaining of fluid for laboratory studies. After the patient has become relaxed and the pressure in the manometer has become stabilized, the nurse or other assistant supports the manometer so that the operator is free to perform the jugular compression test. This is best done from behind. The thumbs are placed on the back of the patient's neck and the index fingers placed on each side of the neck and touching the thyroid cartilage. With proper instruction the patient does not move the head or try to assist the examiner in any way. Simultaneous pressure is applied to the sides of the neck and consequently to the jugular veins. If the spinal subarachnoid space is patent, there is a prompt and steady rise of the fluid in the manometer amounting to 100 or 200 mm. in 10 seconds or less. With removal of jugular compression there is a prompt and fairly steady fall to the original level in approximately the same period of time. The test should be repeated several times. Unilateral jugular compression should never be performed unless the sole purpose of the spinal puncture is to determine which lateral sinus or jugular vein is thrombosed.

If a tumor or arachnoidal adhesions have partially obliterated the subarachnoid space at some point between the foramen magnum and the spinal needle, the fluid in the manometer will rise slowly when jugular compression is applied. There will be a much slower fall of the fluid and perhaps failure to return all the way to the original level. If the spinal subarachnoid space is completely obliterated, the fluid in the manometer will not rise regardless of how high the intracranial pressure is raised with jugular compression. However, if the patient is asked to cough or to contract the abdominal muscles or if the examiner compresses the patient's abdomen, there is a prompt and sharp rise of the fluid in the manometer because these procedures increase the intraabdominal pressure and prevent the intraspinal veins from draining freely into the intra-abdominal veins. To reiterate, in the presence of complete spinal block due to a cord tumor the jugular compression test causes no rise of fluid in the manom-

Thus, a careful examination of the upper extremity should always be made for signs of a sympathetic block, i.e., increase in the skin temperature, dryness and vasodilatation of the peripheral veins. Consequently, if these phenomena are not present, and the block was performed to correct a blood vessel deficiency of the upper extremity, it should be repeated in 30 minutes after reviewing the landmarks. Stellate blocks may be repeated every six to 24 hours, depending on the condition treated. Ordinarily, if a stellate block is beneficial, it is followed by a stellate ganglionectomy, which gives lasting results. Occasionally, when a stellate block is utilized in the treatment of major or minor causalgia, relief of pain will last for several days or weeks.

### SPINAL PUNCTURE

The easiest method of performing a spinal puncture is to have the patient sitting on a stool with the arms and head resting on a table. With the patient in this position it is possible to keep the needle exactly in the midline. This method should be used if the sole purpose of the puncture is to obtain cerebrospinal fluid. However, if the examiner wishes to know something about the intracranial pressure or the patency of the spinal subarachnoid pathways, the puncture should be done with the patient lying on his side with the knees drawn up close to the head. The external occipital protuberance of the skull should be in the horizontal plane of the lumbar spine. The patient is told to relax and is promised that nothing will be done without warning. The operator should describe aloud the preparation of the skin and the other steps as he does them. After the skin has been prepared, two sterile towels are laid in such a way as to permit the operator to rest the left hand on the iliac crest. The third lumbar interspace is approximately in the same transverse plane as the crest of the ilium. Sterile gloves are essential. The space between the third and fourth lumbar spinous processes is firmly palpated with the thumb and with the thumbnail a mark is made between them exactly in the midline. About 2 cc. of procaine is injected into the skin at this point. Nothing is accomplished by injecting procaine into the deeper structures.

Although 22 gauge needles are satisfactory for spinal anesthesia, it is best to use an 18 gauge needle if information is desired regarding intracranial pressure and patency of the spinal subarachnoid space. The needle is pointed in a slightly cephalad direction and kept in the midline. As the spinal canal is approached, the needle is moved forward one centimeter or less at a time and the stylet is removed. Speed accomplishes nothing. It is wise to proceed slowly because it is not always possible to feel the point of the needle puncture the dura. The bevel of the needle is kept in a horizontal position so that longitudinal fibers of the dura will be separated rather than transected. When a flow of spinal fluid is obtained, the stylet is immediately reinserted. A sterile water manometer 300 mm. in length is attached to the needle by means of a three-way stopcock. The second section of the manometer must be ready for attachment if the column of fluid shows signs of rising higher than 300 mm. Rarely does the pressure exceed 600 mm. If the pressure does approach 600 mm., the needle should be quickly withdrawn to prevent further loss of fluid and the patient sent to the hospital with a diagnosis of high intracranial pressure most likely due to a space-taking lesion.

Five minutes or more may be required to obtain a correct pressure reading. The patient must be permitted to change his position slightly to a more comfortable one and one in which the abdominal viscera are not compressed. The neck may be extended somewhat and the lower extremities partially straightened. With proper instructions a patient relaxes the tight masseter muscles, the tensed cervical muscles and the clenched fists. If the puncture is a good one, the cardiac and respiratory fluctuations of the level of the fluid in the manometer will be noted. The patient is asked to tense his abdominal muscles momentarily to demonstrate

terior margin of the foramen magnum with the neural arch of the first cervical vertebra. As in the case of lumbar puncture, the operator can sometimes tell when the point of the needle passes through the dura, which is thick and tough in this region. It is extremely important not to insert the needle any further once the dura and the arachnoid have been perforated. The distance from the skin to the cistern in an adult varies from 4 to 6 cm. The medulla lies 2 to 3 cm. beyond the dura. If the operator thinks that he has perforated the dura but obtains no fluid on removal of the stylet, a syringe should be attached to the needle for aspiration. If the patient is in a sitting position, the pressure in the subarachnoid space at this level will be subatmospheric and the fluid will not run out of the needle. This may also be true if the patient is in the lateral position. Cisternal puncture causes much less discomfort to the patient than lumbar puncture and is rarely followed by a headache.

### SPINAL NERVE BLOCK

Much has been written about the injection of long-lasting anesthetic agents and even destructive agents into or around the spinal nerves in the immediate neighborhood of the intervertebral foramen. The usual purpose of such an injection is to stop an intractable pain which seems to be conducted by the nerve or nerves to be injected. It is also claimed that diagnostic information may be obtained by blocking a nerve root or roots by this method. In spite of the enthusiasm of a few for the therapeutic or diagnostic injection of the spinal nerves, the method is not popular among neurosurgeons if for no other reason than that it is extremely difficult technically and usually painful.

The technique is essentially the same as that described elsewhere in this volume for the injection of procaine into the paravertebral sympathetic chain. In insertion of the needle to the sympathetic chain the point of the needle must pass near the spinal root. One of the difficulties of sympathetic block is that the spinal nerve may be struck by the point of the needle during its insertion.

If a spinal root is to be injected for any reason, it is best to carry out the procedure on the x-ray table. If the point of the needle does not strike the root and produce radicular pain, it can be inserted until the point strikes the lateral aspect of the vertebral body, as for a sympathetic block. The exact position of the needle can then be determined by making a roentgenogram. The needle is then withdrawn the required 1 or 2 cm. One is then certain that the point of the needle is close to the root. The anesthetic can be injected at this point, or perhaps the operator will wish to measure the exact length of the protruding shaft and then probe until the nerve is struck.

### CEREBRAL ANGIOGRAPHY[32]

Cerebral angiography can be performed in the office by percutaneous injection of a contrast medium into the common carotid artery, provided the necessary roentgenographic equipment is available. The procedure is used mainly to diagnose brain tumors, aneurysms of the circle of Willis, cerebrovascular anomalies and stenoses or thromboses of the carotid artery in the neck. An aqueous solution of 50 per cent Hypaque sodium is the contrast medium most commonly used. Before intra-arterial injection of the contrast medium a sensitivity test should be performed. A 1 cc. solution injected intravenously is likely to indicate sensitivity.

*Technique.* The premedicated patient is placed in the supine position on the x-ray table with the head and neck on the rapid casette changer. The skin of the neck is prepared, and sterile towels are placed over the chest and shoulders. The common carotid artery is palpated 3 cm. above the clavicle, and the skin in this area is anesthetized by intradermal injection of 1 or 2 cc. of a 1 per cent solution of procaine. If the common carotid artery is injected at this level, the distal inch of the common carotid, as well as all the internal and external carotid arteries, will be visualized. Con-

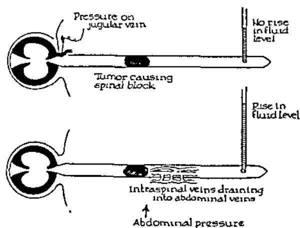



*Figure 346.* If a complete spinal block exists, abdominal compression causes elevation of fluid in the manometer but jugular compression does not.

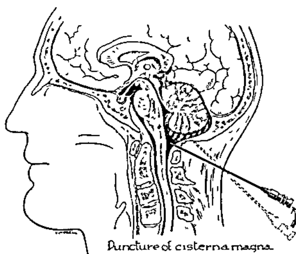



*Figure 347.* Needle inserted and pointed in direction of bridge of nose for cisternal puncture.

eter, but coughing and straining cause a prompt rise and a fall to the original level (Fig. 346).

If complete or partial spinal subarachnoid block is demonstrated with the jugular compression test, and if the clinical diagnosis is spinal cord tumor, 2 cc. of Pantopaque *should be injected* through the lumbar puncture needle before the needle is withdrawn. This permits localization of the lower pole of the tumor by fluoroscopy on the same day or the next day without repeating the spinal puncture.

If the clinical diagnosis is poliomyelitis or some form of meningitis, the primary purpose of the puncture is to obtain fluid for bacteriologic and other studies. However, it is well to perform the jugular compression test before withdrawing the fluid, as epidural spinal abscess and a few other conditions may simulate meningitis.

### CISTERNAL PUNCTURE

Although spinal fluid can be obtained just as easily by cisternal puncture as by lumbar puncture, the latter continues to be the method of choice because it is safer. In the performance of a cisternal puncture it is theoretically possible to puncture the medulla or one of the vertebral arteries. However, there should be no hesitation in performing a cisternal puncture if difficulty is had in obtaining fluid by lumbar puncture or if the skin in the lumbar region is infected. Also, cisternal puncture with the introduction of radiopaque oil is used frequently as a diagnostic measure in cases of spinal cord tumor. By this method it is possible to demonstrate roentgenologically the upper pole of the tumor or the uppermost tumor in the case of multiple *spinal tumors. Cisternal puncture is contraindicated* in patients with greatly increased intracranial pressure, in patients in whom herniation of the cerebellar tonsils is suspected, and in those with local sepsis of the posterior cervical or suboccipital regions.

After the upper part of the back of the neck has been shaved, the skin is prepared and draped as for a lumbar puncture. The puncture can be performed with the patient in the lateral or sitting position. A wheal of procaine is made over the spinous process of the second cervical vertebra. This is the highest spinous process that is palpable. The first cervical vertebra does not have a spinous process but merely a small tubercle. An 18 gauge spinal puncture needle is inserted and pointed in the direction of the bridge of the nose (Fig. 347). *It is important to keep the needle* exactly in the midline and to have it strike the base of the skull posterior to the foramen magnum When the skull is encountered, the needle is withdrawn slightly and pointed in a more anterior direction. The skull may be encountered several times before the needle pierces the ligaments which connect the pos-

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sequently, since most arteriosclerotic plaques causing stenosis of the internal carotid artery form 1 cm. distal to the bifurcation of the common carotid artery, this region will be adequately demonstrated, and by cannulation of the common carotid artery at a lower level, it will be assured that the needle will not impinge on the bifurcation of the carotid and cause an artefact.

There are several methods of performing cerebral angiography, all of which are satisfactory, depending on the experience and preference of the angiographer. One method is to insert a straight or curved 18 gauge needle directly into the artery. This is done by first palpating the artery and inserting the needle into the subcutaneous tissues so that the point of the needle lies between the palpating finger and the artery. Then, with the artery located accurately, it is simple to insert the needle into the lumen of the artery The needle is then threaded into the lumen for 1 or 2 centimeters. A two-way stopcock is attached directly to the needle, to which a syringe containing saline solution is attached for intermittent injection to keep the system open. The syringe containing the saline solution is eventually exchanged for one containing the radiopaque medium. Some angiographers attach a polyethylene tube to the needle and attach a three-way stopcock to the opposite end of the tube. Thus, a syringe of saline can be used for irrigation on one of the outlets of the stopcock while the other is attached to a syringe of Hypaque sodium for injection. The disadvantage of the former method is that the slightest movement of the head will occasionally dislodge the needle. Dislodgement of the needle can be prevented by cannulating the common carotid artery with a thin-walled No. 15 needle through which a No. 18 polyethylene tube is threaded into the lumen of the carotid artery. Once the tubing is in place, the head may be positioned and moved at will to make as many exposures as may be required without fear of dislodging the tube. After the artery has been adequately cannulated, a few minor adjustments by the radiology technician are usually required to position the head correctly. During this interval, the patient is instructed not to move the head when the dye is injected, as this will cause a burning pain in the neck, face and head.

The 10 cc. of dye is injected as rapidly as possible, and the technician is signaled to expose the films when 1 or 2 cc. of dye is left in the syringe. With the rapid casette changer, the films may be arranged so that 32 exposures may be taken in six seconds. Some roentgenographic units will take simultaneous anteroposterior and lateral projections. However, in the usual case, three anteroposterior and three lateral views made at one-second intervals show the cerebral, arterial, capillary and venous phases. Next, a second injection is made, with use of contralateral digital compression of the common carotid artery so that some of the radiopaque medium will cross in the communicating arteries of the circle of Willis to give partial filling in the vessels in the contralateral hemisphere and thus demonstrate adequacy of the circle. One lateral projection is all that is necessary for visualization of the carotid arteries in the neck. Usually, 4 cc. is the amount of each injection of contrast medium for adequate visualization of the carotid arteries in the neck, whereas 10 cc. is the usual amount to demonstrate the cerebral vessels. The films are developed immediately after each injection. After satisfactory angiograms have been made, the needle is withdrawn, and moderate digital pressure is applied to the neck for three or four minutes to prevent a hematoma. Bilateral carotid angiography is indicated in most patients.

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